

VOLUME II: CHAPTER 7

PREFERRED AND ALTERNATIVE METHODS FOR ESTIMATING AIR EMISSIONS FROM SURFACE COATING OPERATIONS

October 1997



Prepared by:
Eastern Research Group, Inc.

Prepared for:
Point Sources Committee
Emission Inventory Improvement Program

DISCLAIMER

This document was furnished to the Emission Inventory Improvement Program and the U.S. Environmental Protection Agency by Eastern Research Group, Inc., Morrisville, North Carolina. This report is intended to be a final document and has been reviewed and approved for publication. The opinions, findings, and conclusions expressed represent a consensus of the members of the Emission Inventory Improvement Program. Any mention of company or product names does not constitute an endorsement; rather the names are used as examples.

ACKNOWLEDGEMENT

This document was prepared by Eastern Research Group, Inc., and Radian International LLC, for the Point Sources Committee, Emission Inventory Improvement Program and for Dennis Beauregard of the Emission Factor and Inventory Group, U.S. Environmental Protection Agency. Members of the Point Sources Committee contributing to the preparation of this document are:

Dennis Beauregard, Co-Chair, Emission Factor and Inventory Group, U.S. Environmental Protection Agency
Bill Gill, Co-Chair, Texas Natural Resource Conservation Commission
Denise Alston-Guiden, Galson Consulting
Bob Betterton, South Carolina Department of Health and Environmental Control
Paul Brochi, Texas Natural Resource Conservation Commission
Alice Fredlund, Louisiana Department of Environmental Quality
Gary Helm, Air Quality Management, Inc.
Paul Kim, Minnesota Pollution Control Agency
Toch Mangat, Bay Area Air Quality Management District
Ralph Patterson, Wisconsin Department of Natural Resources
Jim Southerland, North Carolina Department of Environment, Health, and Natural Resources
Eitan Tsabari, Omaha Air Quality Control Division
Bob Wooten, North Carolina Department of Environment, Health, and Natural Resources

This page is intentionally left blank.

CONTENTS

Section	Page
1 Introduction	7.1-1
2 Source Category Descriptions	7.2-1
2.1 Common Terms Used to Describe Surface Coating Operations	7.2-2
2.1.1 Coatings	7.2-2
2.1.2 Coating Application	7.2-5
2.1.3 Auxiliary Process	7.2-10
2.1.4 Air Pollution Control Techniques and Pollution Prevention	7.2-11
2.2 Surface Coating Source Categories	7.2-13
2.2.1 Aircraft Manufacturing	7.2-15
2.2.2 Appliances	7.2-15
2.2.3 Automobiles and Light-duty Trucks	7.2-16
2.2.4 Heavy-duty Truck Manufacturing	7.2-17
2.2.5 Automobile Refinishing	7.2-17
2.2.6 Flat Wood Product Manufacturing	7.2-17
2.2.7 Magnet Wire	7.2-18
2.2.8 Metal Cans (Two- or Three-piece)	7.2-19
2.2.9 Metal Coil	7.2-19
2.2.10 Metal Furniture	7.2-20
2.2.11 Miscellaneous Metal Parts	7.2-20
2.2.12 Paper Coating	7.2-21
2.2.13 Plastic Parts	7.2-23
2.2.14 Ships	7.2-23
2.2.15 Wood Furniture Coating	7.2-24
3 Overview of Available Methods	7.3-1
3.1 Emission Estimation Methods	7.3-1
3.1.1 Material Balance	7.3-1
3.1.2 Source Sampling	7.3-2
3.1.3 Predictive Emission Monitoring (PEM)	7.3-2
3.1.4 Emission Factors	7.3-3
3.2 Comparison of Available Emission Estimation Methodologies	7.3-3

CONTENTS (CONTINUED)

Section	Page
4	Preferred Methods for Estimating Emissions 7.4-1
4.1	Calculation of VOC Emissions Using Material Balance (Vented and Open Coating Operations) 7.4-3
4.2	Calculation of Speciated VOC Emissions Using Material Balance 7.4-10
4.3	Calculation of Emissions for Multiple-part Coatings 7.4-11
4.4	Calculation of PM/PM ₁₀ Emissions Using Material Balance (Open Coating Operations) 7.4-14
4.5	Calculation of PM/PM ₁₀ Emissions Using Source Testing Data (Vented Coating Operations) 7.4-19
5	Alternative Methods for Estimating Emissions 7.5-1
5.1	Predictive Emission Monitoring (PEM) 7.5-1
5.2	Emission Factor Calculations 7.5-1
5.3	Emissions Calculations Using Source Testing Data 7.5-4
5.4	Calculation of PM/PM ₁₀ Emissions From Vented Coating Operations Using Material Balance 7.5-6
6	Quality Assurance/Quality Control 7.6-1
6.1	General Factors Involved in Emission Estimation Techniques 7.6-1
6.1.1	Material Balance 7.6-1
6.1.2	Source Testing and PEM 7.6-3
6.1.3	Emission Factors 7.6-3
6.2	Data Attribute Rating System (DARS) Scores 7.6-3
7	Data Coding Procedures 7.7-1

CONTENTS (CONTINUED)

Section	Page
7.1 Source Classification Codes	7.7-1
7.2 AIRS Control Device Codes	7.7-2
8 References	7.8-1
Appendix A: Example Data Collection Form Instructions for Surface Coating Operations	

FIGURES AND TABLES

Figure	Page
7.6-1 Example Emission Inventory Checklist for Surface Coating Operations	7.6-2

Tables	Page
7.2-1 Standard Industrial Classification (SIC) Codes for Surface Coating Source Categories	7.2-14
7.3-1 Summary of Preferred and Alternative Emission Estimation Methods for Surface Coating Operations: Vented Coating Operations	7.3-4
7.3-2 Summary of Preferred and Alternative Emission Estimation Methods for Surface Coating Operations: Open Coating Operations	7.3-5
7.4-1 List of Variables and Symbols	7.4-2
7.4-2 Distribution of VOC Emissions Emitted During Surface Coating Operations for Selected Industries	7.4-5
7.5-1 List of Variables and Symbols	7.5-2
7.5-2 Predictive Emission Monitoring Analysis	7.5-3
7.6-1 DARS Scores: Material Balance	7.6-5
7.6-2 DARS Scores: Source Sampling	7.6-6
7.6-3 DARS Scores: Predictive Emissions Monitoring	7.6-7
7.6-4 DARS Scores: Emission Factors	7.6-8
7.7-1 Source Classification Codes for Surface Coating Operations	7.7-3
7.7-2 AIRS Control Device Codes	7.7-20

1

INTRODUCTION

The purposes of the preferred methods guidelines are to describe emission estimation techniques for point sources in a clear and unambiguous manner and to provide concise example calculations to aid regulatory and non-regulatory personnel in the preparation of emission inventories. While emissions estimates are not provided, this information may be used to select an emissions estimation technique best suited to a particular application. This chapter describes the procedures and recommends approaches for estimating emissions from surface coating operations.

Section 2 of this chapter contains definitions of terms commonly used to describe surface coating operations and general descriptions of major surface coating source categories. Section 3 of this chapter provides an overview of available emissions estimation methods. Section 4 presents the preferred method for estimating emissions from surface coating operations and Section 5 presents the alternative emission estimation techniques. Quality assurance and control procedures associated with the emission estimation methods are described in Section 6. Coding procedures used for data input and storage are discussed in Section 7. Some states use their own unique identification codes, so non-regulatory personnel developing an inventory should contact individual state agencies to determine the appropriate coding scheme to use. References cited in this document are provided in Section 8.

Appendix A provides example data collection forms to assist in information gathering prior to emissions calculations. During the inventory planning phase, the preparer should decide whether a source category should be inventoried as a point or area source. Data collection activities should be planned accordingly.

This page is intentionally left blank.

2

SOURCE CATEGORY DESCRIPTIONS

This section presents a general discussion of surface coating terms and a description of source categories that are known to use surface coating in many production activities. For a more detailed discussion of surface coating and these categories, refer to *AP-42* or the regulatory documents applicable to the specific source (EPA, 1995a). There may be many other source categories that also utilize surface coating; the principles and emissions estimating procedures discussed here are likely to apply to these sources as well.

There are many different types of coatings that are used in the surface coating industry such as paints, varnishes, printing inks, polishes, sealers, etc. Typically, coatings provide protection or decoration to a substrate or surface. In a typical coating sequence, three types of coatings are used: a primer, an intermediate coat, and a topcoat.

The majority of emissions that occur during surface coating are due to evaporation of the solvents contained in the coatings. The most common solvents are organic compounds such as ketones, esters, aromatics, and alcohols. To obtain or maintain certain application characteristics, solvents are also added to coatings immediately before use. Other ingredients of the coatings, such as metals and particulates, may also be emitted during coating operations.

A wide variety of materials is used in surface coatings. In general, coatings can be divided into two classifications: thermoplastic and thermoset. Thermoplastics can be dissolved back into a liquid state by their original thinner or other selected solvents, and dried by solvent evaporation only. Examples of thermoplastic coatings include vinyls and lacquers. Thermoset coatings are materials that cannot be returned to their original state by contact with their original thinner or most other solvents. These coatings cure by solvent evaporation and chemical cross-linking of the coating components. Examples of thermoset coatings include epoxies, enamels, and urethanes.

Surface coating may be performed in a spray booth or in an open environment. Some previously open surface coating operations have been enclosed and the exhaust vented through a stack. Surface coatings may be applied manually or with automatic devices such as spray guns.

2.1 COMMON TERMS USED TO DESCRIBE SURFACE COATING OPERATIONS

2.1.1 COATINGS

Enamels

Enamels are thermoset topcoatings that can be either acrylic- or alkyd-based. Acrylic enamels require catalysts to facilitate curing. An alkyd enamel is a mixture of an alcohol, an acid, and an oil. Both types have a natural high gloss. Enamel coatings have a longer drying time than lacquer coatings.

Guide Coatings

A guide coating, also called a primer surface, is applied between the primer and the topcoat to build film thickness, to fill in surface imperfections, and to permit sanding between the primer and topcoat. Guide coats are applied by a combination of manual and automatic spraying and can be solventborne, waterborne, or powder. Guide coating is used especially after electrodeposition (EDP).

High-solids Coatings

Coatings that typically contain greater than 60 percent solids by volume are referred to as high-solids coatings (Environmental Protection Agency [EPA], 1992). High-solids coatings require less solvent content, therefore, volatile organic compound (VOC) emissions reductions ranging from 50 to 80 percent can be achieved by converting to coatings that contain higher solids. High-solids coatings can be applied electrostatically or manually by roll coating or spraying. Because of the higher viscosity of high-solids coatings, additional mechanical, thermal, or electrical energy may be necessary for pumping and adequate atomization. Transfer efficiencies are usually better than those achieved through conventional coatings, especially when sprayed electrostatically. In addition, because there is less solvent in high-solids coatings, the minimum air flow required for dilution of air in a spray booth may be reduced, resulting in an energy savings for fan operation.

Intermediate or Midcoat

The intermediate coat serves to seal the primer and fill any voids or porosities in the primer coat. They also provide an additional layer of corrosion protection by acting as a barrier coat. An intermediate/midcoat also provides a surface to which subsequent coats can adhere. In instances

where a primer and a topcoat are not compatible (such as a thin film topcoat and a zinc-filled primer), intermediate coats can serve as a tie coat between the two coats.

Lacquers

Lacquers are thermoplastic topcoatings that dry faster than most enamels and urethanes, making them more attractive to sources (e.g., automobile body shops) that do not have spray booths. Lacquer finishes, however, are not as durable as enamel and urethane finishes.

Powder Coatings

Powder coatings are applied electrostatically by spraying or dipping, or by dipping a preheated object into a fluidized bed of coating. After a powder coating is applied to an object, the object is placed in an oven to melt the powder particles and create a flow to form a continuous, solid film.

Electrostatic powder spray coating can be performed automatically or manually. As charged powder particles leave a spray gun, they are attracted to the grounded object that is to be coated. With this method, powders are able to wrap around edges of complicated forms. Film thickness can be controlled by adjusting the voltage. Like conventional spraying, powder spraying requires a booth. However, the ventilation requirements for powder spray booths are much less stringent than for solvent coating spray booths if the powder is applied automatically and the booth is therefore not occupied.

Dipping is also used to apply powder coatings. There are two ways that powders can be applied by dipping: fluidized bed or electrostatic fluidized bed. In a fluidized bed, a preheated object is immersed into the bed and held there until a desired film thickness is reached. In electrostatic fluidized bed coating, the powder particles are attracted to grounded, usually unheated, objects moving through the bed. A disadvantage of dipping is that powder coatings can only be applied in thick films.

Although powders are essentially 100 percent solids, they may contain small quantities of entrapped organic solvent. During the curing process, these organics may be released due to unblocking and cross-linking reactions. Up to 10 weight percent of VOCs can be released from powders during the curing process. Most powder overspray can be reclaimed and reused; however, some reclaimed overspray must be reprocessed because it may contain larger and heavier granules that are not acceptable for reuse.

Primer

The primer is the first film of coating applied in a coating operation that facilitates bonding between the surface and subsequent coats. Without adequate primer adhesion to the surface, the

subsequent coatings may not adhere properly. In addition, primers serve to prevent corrosion in one of three ways: physically, as a barrier; chemically, with the use of corrosion-inhibiting agents; or electrochemically. Primers also prevent dulling of the topcoat caused by the penetration of topcoat solvents into the lower coat(s). If imperfections remain on the surface after primer application, a primer surfacer may be applied to build thickness and smooth over any imperfections. Some primers are water-based and contain little or no organic solvent.

Topcoat

The topcoat is the final film of coating applied after a surface has been prepared and is free of defects. Topcoats provide the final color and appearance. They also provide additional resistance to the environment and help protect the primer and intermediate coats from exposure to weather and chemicals. Topcoats may be single-, two-, or three-stage coating systems. An oven bake may follow each topcoat application, or the coating may be applied wet on wet. The final topcoat may be baked in a high-temperature oven. Two-stage systems may have either a solid color or metallic basecoat, covered with a transparent clearcoat for protection. These systems are eye appealing because of their deep, rich finish. Three-stage systems consist of a basecoat, midcoat, and clearcoat. Topcoats have traditionally been solventborne lacquers and enamels. Recent trends have been to use topcoats with higher solids content, such as powder topcoats.

Ultraviolet (UV) Coatings

UV coatings are formulated to cure at room temperature with the assistance of UV light. Photoinitiators in the coating act as catalysts. Upon adsorption of UV light, the photoinitiators cleave to yield free radicals that begin the polymerization process. No VOC emissions occur from using UV coatings.

Urethanes

Urethanes are thermoset topcoatings formed by a chemical reaction between a hydroxyl-containing material and a polyisocyanate catalyst. Urethane coatings have a higher volume percentage of solids content than lacquers and a slightly higher percentage than enamels. Urethane coatings are popular because of their superior gloss retention, durability, corrosion protection, and versatility. This coating type is strongly adherent to metal surfaces and can resist both chemical attack and abrasion. Their clarity and resistance to weather make them valuable for severe industrial service. Urethane coatings dry more slowly than lacquer or enamel coatings and, because of the slower drying time, spray booths are often required to provide a clean, dust-free curing environment.

Vinyl Coatings

Coatings that are based on vinyl resins formed by the polymerization of vinyl compounds are called vinyl coatings. The most common resins are based on polyvinyl chloride (PVC) copolymers. These resins form films by solvent evaporation. Freshly applied coatings are dry to the touch within one hour and are fully dried within seven days. Vinyl coatings are particularly useful when fast drying, particularly at low temperatures (0 to 10°C [32 to 50°F]), is required.

Coatings based on vinyl polymers perform well in immersion situations and are frequently used to protect submerged structures such as the underwater hull of a ship. These coatings have excellent resistance to many chemicals and are good weather-resistant materials. Vinyl coatings are softened by heat and are not suitable for sustained use above 66°C (150°F). Vinyl paint systems require the use of a thin coat of wash primer (containing acids to etch the surface) as the first coat to ensure good adhesion to steel.

Waterborne Coatings

Coatings manufactured using water as the primary solvent are referred to as waterborne or water-based coatings and offer some advantages over organic solvent systems because they do not exhibit as great an increase in viscosity with increasing molecular weight of solids, are nonflammable, and have limited toxicity. There are three major classes of waterborne coatings: water solutions, water emulsions, and water dispersions. All of the waterborne coatings, however, contain a small amount (up to 20 percent of volume) of organic solvent that acts as a stabilizing, dispersing, or emulsifying agent. Because of the relatively slow evaporation rate of water, however, it is difficult to achieve a smooth finish with waterborne coatings. A bumpy "orange peel" surface often results. For this reason, their main use is as a prime coat.

Waterborne primer is most often applied in an electrodeposition bath. The composition of the bath is about 5 to 15 volume percent solids, 2 to 10 volume percent solvent, and the rest water. The solvents used are typically organic compounds of higher molecular weight and low volatility, like ethylene glycol monobutyl ether (EPA, 1995a).

2.1.2 COATING APPLICATION

Brush Coating

Coating applied with a brush is called brush coating. A transfer efficiency of 100 percent may be achieved using this method. However, brush coating is not a practical method for painting large parts.

Dip Tanks

Objects to be coated are immersed manually or by conveyor into a dip tank full of coating. After removal from the tank, any excess coating is allowed to drain back into the tank. Dip coating operations can be totally enclosed and vented by a roof exhaust system, or may have a ventilation system adjoining the dip tank. The advantages of dip coating include minimal coating loss. Dip coating operations are common (but not limited) to the following industries; metal furniture, miscellaneous metal parts, aircraft, appliances, automobiles, and light-duty trucks.

Electrodeposition

In EDP, a direct-current voltage is applied between the coating bath (or carbon or stainless-steel electrodes in the bath) and the part to be coated. The part, which can act as the cathode or the anode, is dipped into the bath. Coating particles are attracted from the bath to the part because they are oppositely charged, yielding an extremely even coating. The coatings used in EDP tanks are waterborne solutions. Transfer efficiencies for EDP are commonly above 95 percent (Turner, 1992).

Flash

Flash refers to the evaporation of solvents (VOC) from a coated product from the time the product is coated until the product reaches the dryer/curing oven. If the product is air dried, VOCs flash off the product until the product is dry or until all VOCs are evaporated. The evaporated VOCs will either be collected by a capture system or be released as a fugitive emission.

Flow Coating

Flow coating is a coating process by which the object to be coated is conveyed over an enclosed sink where pumped streams of coating are allowed to hit the object from all angles, flow over the object and coat it, and drip back into the sink. Typically, a series of nozzles (stationary or oscillating) are positioned at various angles to the conveyor, and shoot out streams of coating that "flow" over the object. Flow coating can achieve up to 90 percent transfer efficiency. Examples of industries using flow coating include automobile, flat wood paneling, metal furniture, and miscellaneous metal parts.

"Vacuum coating" is a kind of flow coating. The coating chamber is flooded with coating and vacuum pulls the coating across the product.

"Curtain coating" is also a type of flow coating. In this process, the coating is not pumped from all angles but instead cascades over the part as a waterfall. Curtain coating is used mostly for flat goods.

Phosphating

Phosphating is a process that prepares metal surfaces for the primer application. Since iron and steel rust readily, a phosphate treatment is necessary. Phosphating also improves the adhesion of the primer and the metal. The phosphating process occurs in a multistage washer, with detergent cleaning, rinsing, and coating of the metal surface with zinc or iron phosphate. The metal surfaces then pass through a water spray cooling process. If solventborne primer is to be applied, they are oven-dried prior to priming.

Roller Coating

Roller coating machines typically have three or more power-driven rollers. One roller runs partially immersed in the coating and transfers the coating to a second, parallel roller. The strip or sheet to be coated is run between the second and third roller and is coated by transfer of coating from the second roller. If the cylindrical rollers move in the same direction as the surface to be coated, the system is called a direct roll coater. If the rollers move in the opposite direction of the surface to be coated, the system is a reverse roll coater (EPA, 1995a). The quantity of coating applied to the sheet or strip is established by the distance between the rollers.

Spray Booths

Spray booths provide a clean, well-lit, and well-ventilated enclosure for coating operations. Coatings that have long drying times are best applied in spray booths to minimize potential dust and dirt from adhering to a wet coating. Some spray booths are equipped with a heating/baking system that promotes faster drying times. Some facilities use portable heating units that can be rolled into a spray booth after an object has been painted. Some spray booths draw in air through filters to assure a flow of clean air over the object to be coated, and other booths draw in air through unfiltered openings. Air is drawn out of the booth to promote drying and to provide a safer working environment for the painter by removing solvent vapors from the work area. Filters for the discharge from the booth remove coating overspray (the portion of the coating solids that does not adhere to the surface being sprayed) from the exhaust air.

The three most common types of spray booths are: crossdraft, downdraft, and semi-downdraft. Crossdraft spray booths operate by pulling incoming air into the booth at one end, with air crossing over the object being coated and then passing out of the booth at the opposite end. Downdraft booths employ a vertical air flow from the top to the bottom of the booth. Because downdraft booths provide the cleanest drying/curing environment with low air turbulence and increased worker safety, they are regarded as state-of-the-art. Semi-downdraft booths are available that combine both crossdraft and downdraft booth designs. Air enters the booth through the ceiling (like a downdraft booth) and exits at the back of the booth (like a crossdraft booth).

Spray Equipment

Spray equipment includes conventional air spray guns such as electrostatic, high volume/low pressure, and low volume/low pressure, and airless spray guns, and spray guns that utilize carbon dioxide injection.

Airless Spray Systems. Hydraulic pressure alone is used to atomize the fluid at high pressure (400-4,500 pounds per square inch [psi]) through a small orifice in the spray nozzle. Upon exiting the spray nozzle at high pressure, the fluid breaks up into fine droplets resulting in a fine atomized spray. Since the coating is discharged at a high velocity after atomization, sufficient momentum remains to carry the small particles to the surface being coated. The pressure required to properly atomize the fluid depends on the viscosity of the material being applied. Airless spray systems are cleaner and faster to use than conventional spray systems. Coatings can be applied as fast as the painter can move the gun and as thick as desired. The primary advantage of the airless spray method is that it greatly reduces particle "bounce" (i.e., coating particles that ricochet off the substrate surface), often to less than half of what might occur while using conventional spray equipment. In addition, low overspray and significant material savings are benefits of airless spray systems. The primary problem observed with airless spray systems is nozzle plugging. Due to very minute nozzle orifices, coatings fed to the gun must first pass through filters with openings slightly larger than the nozzle orifice. Since filters are usually located at the pump discharge, deposits on the filters may cause plugging.

Carbon Dioxide (CO₂) Injection Spray Systems. CO₂ injection spray systems are a relatively new spray technology that uses supercritical CO₂ to replace the solvent that is normally present in conventional coatings. The CO₂ is mixed with the coating concentrate as the coating is sprayed. The spray solution generally contains 10 to 50 percent by weight of dissolved CO₂, depending upon the solubility, solids level, pigment loading, temperature, and pressure. To preserve the CO₂ in solution, the gun pressure is maintained at 1,200 to 1,600 psi (i.e., pressures typical of airless spraying). Due to the rapid decrease in temperature as the CO₂ expands through the nozzle, the solution is typically heated to 100 to 160°F (38 to 71°C). The transfer efficiency of this system approaches that of a conventional airless spraying system. There are several disadvantages of this system though, such as a slower fluid delivery rate than exists for conventional air guns, lack of coatings formulated to allow for application with CO₂ injection, and high capital cost.

Conventional Spray Guns. Conventional guns are hand-held guns that use air pressure to atomize a coating. Conventional air spray guns provide a fine decorative-type finish and allow precise spray adjustments by the operator. The coating and air enter the gun through separate passages and are mixed and discharged through an air nozzle, providing a controlled spray pattern. There are three basic types of conventional spray guns: vacuum type, pressure type, and gravity type.

Conventional vacuum spray guns contain the coating in a cup that is directly attached to the spray gun. The swift air flow through the air line and spray gun creates a vacuum that siphons coating from the cup and forces it through the gun nozzle. Since this system must be filled often, it is best suited for spot painting, as opposed to applications requiring larger amounts of coating. Also, it is difficult to achieve proper atomization of some modern coatings.

Conventional pressure spray guns contain the coating in a "pot" that is attached by fluid hose lines to the spray gun. By introducing compressed air to the pot, the liquid is pushed through the hose and out of the spray nozzle. Pressure-type systems are normally used when large amounts of material are required, when the material is too heavy to be siphoned from a container, or when fast application is required.

Conventional gravity-fed spray guns contain the coating reservoir (cup) above the gun, thus requiring less air pressure to force the coating through the gun. Gravity-fed guns provide substantially better transfer efficiency than vacuum guns.

Electrostatic Spray. Electrostatic spray is a method of applying a spray coating in which opposite electrical charges are applied to the substrate and the coating. The coating is attracted to the substrate by the electrostatic potential between them. The system works best when used in surface coating operations where the objects to be coated are relatively small and uniform in density. Varying densities may present problems because higher density areas can be more conductive, thus attracting more coating material than an area that is less dense. With large objects, it can be difficult to attain a good ground. Grounding also becomes increasingly difficult as each additional layer of coating is applied. These systems are generally accepted as providing the highest transfer efficiency possible. Unfortunately, the applicability of electrostatic spray systems tends to be limited due to the principles employed.

Low Volume/Low Pressure (LVLP) Spray Systems. LVLP spray guns atomize coatings, and the atomized spray is discharged at low pressure (9.5-10 psi) and lower velocities than conventional air spray guns. The transfer efficiency of LVLP spray guns is approximately the same as for HVLP spray guns. The main difference between the two types is that LVLP guns use a significantly smaller volume of air for coating atomization (45 to 60 percent less). As a result, energy costs for air compression are lower than for HVLP spray guns.

High Volume/Low Pressure (HVLP) Spray Systems. With HVLP spray systems, low pressure (typically 10 psi or less) is used with large volumes of air to atomize coatings. The air source for an HVLP system can be conventional compressed air or a turbine. Most HVLP systems are designed to be compatible with a wide range of coatings. Because the atomized spray exits the gun at a lower velocity than in conventional air spraying, there is less particle bounce. Consequently, higher transfer efficiencies can be obtained with a reduction in overspray. Higher transfer efficiencies and reduced overspray both contribute to lower VOC emissions. HVLP

systems are also noted for their good operating control, portability, ease to clean, and ability to spray well into recesses and cavities. Disadvantages of HVLP spray systems include slow application rate, high maintenance cost, and increased operator training.

Transfer Efficiency

The ratio of the amount of coating solids deposited onto the surface of the coated object to the total amount of coating solids that exit the coating device is referred to as transfer efficiency. Coating that is sprayed but fails to deposit on the surface to be coated is referred to as "coating overspray." Increased transfer efficiency results in less overspray. The level of transfer efficiency is usually used in a description of spray devices.

High transfer efficiency has several benefits: reduces the amount of coating used and, consequently, reduces emissions; reduces solvent concentration around the worker; reduces time spent in applying coatings, since more coating reaches the substrate; and reduces the amount of solvent needed for overspray cleanup.

The transfer efficiency of spray equipment is influenced by several factors including the shape of the surface being coated, type of gun, velocity of the aerosol, skill and diligence of the operator, and extraneous air movement within the spray area (or booth).

Typical transfer efficiencies can be obtained from equipment manufacturers or technical references such as *AP-42* (EPA, 1995a).

2.1.3 AUXILIARY PROCESS

Cleaning

Surface coating application equipment is cleaned with solvent cleaners. Spray guns can be cleaned manually or with several different types of gun cleaning systems specially designed for this purpose. Cleaning of equipment results in VOC emissions. Solvent emissions from gun cleaning equipment occur both during actual cleaning operations ("active losses") and during standby ("passive losses") periods.

2.1.4 AIR POLLUTION CONTROL TECHNIQUES AND POLLUTION PREVENTION

Emissions from surface coating operations may be vented directly to the atmosphere, released as fugitive emissions, or routed to an air pollution control device or pollution prevention system. The following discussion presents air pollution control techniques and pollution prevention alternatives that may be used to reduce either VOC or particulate matter (PM) or PM less than or equal to an aerodynamic diameter of 10 μm (PM₁₀) emissions. It should be noted that any

particular control technique may be very effective at removing one pollutant from the exhaust stream, but may have no effect on other pollutants.

Capture

Capture systems may be used to collect the evaporated VOC emissions by vacuum or other exhaust mechanism and direct them to a control device or vent the VOCs to the atmosphere. Capture systems may not collect all VOCs allowing some to escape as fugitive emissions.

Carbon Adsorption

Carbon adsorption refers to a control system where the collected coating exhaust is passed over a bed of carbon where pollutants are adsorbed and collected. Carbon adsorption units work best with lower-temperature operations. It is important to remove any entrained liquids and PM that may be in the inlet gas prior to passing through a carbon adsorber to avoid plugging up the carbon bed and reducing its adsorption efficiency.

Recovery of solvents that have been adsorbed onto carbon beds is common. When a mixture of solvents is collected, the recovered mixture is often used as fuel to fire a boiler or other fuel-consuming process unit. In some facilities, the mixture is separated by distillation, and the recovered solvents are reused (EPA, 1977a, 1977b). If properly operated and maintained, VOC control efficiencies as high as 98 percent can be achieved.

Catalytic Incineration

Incineration where a catalyst is used to lower the activation energy needed for oxidation is referred to as catalytic incineration. When a waste gas stream passes through a catalytic incinerator, the catalyst bed initiates and promotes the oxidation of VOCs without being permanently altered itself. Catalytic-aided combustion takes place at a considerably lower temperature than in noncatalytic incineration (EPA, 1978). Major disadvantages of catalytic incineration include the need to replace the catalyst because of pollutant poisoning and the high cost of catalyst replacement. VOC control efficiencies of 99 percent can be achieved through the use of incinerators.

Combination Adsorption/Incineration Systems

A control system that incorporates carbon adsorption and catalytic or thermal incineration is available for emissions control. With these types of systems, the contaminants from a waste gas stream are initially collected on a carbon adsorption bed. A smaller volume of air is used for regeneration and then sent to an incinerator. As a result, a smaller incinerator is needed for these systems than what would be required for a conventional thermal incinerator. These systems are

capable of achieving 90 percent control (Eisenmann Corporation). In addition, by concentrating the VOCs in the gas stream, fuel costs for incineration are reduced. The primary disadvantage of these systems is that high capital investment is required.

Dry Filters

PM emissions from spray booths can be controlled with dry filters that capture PM before entering the exhaust air. When the filters become loaded with PM to the point that the pressure drop across the filters reaches a certain level, they must be replaced.

Solvent Recovery

Solvent recovery is a pollution prevention technique that can be used to reduce emissions. Solvent condensation is one such technique capable of recovering a reusable solvent. Carbon adsorption is another type of solvent recovery often used and was described earlier.

Thermal Incineration

Thermal incineration is the process of raising waste gas to a temperature that is adequate to oxidize organic compounds. The most important factors to ensure proper oxidation include the following: temperature in the combustion chamber, time that the VOC-laden exhaust air resides in the combustion chamber, mixing of the gaseous components before and within the combustion chamber, oxygen content of the waste gas stream, and the type of contaminants present in the waste gas stream (EPA, 1992; Eisenmann Corporation). The products of incineration are water, CO₂, nitrogen oxides (NO_x), and carbon monoxide (CO).

Many thermal incinerators use heat exchangers to reduce fuel costs. In recuperative heat exchange designs, a heat exchanger upstream of the incinerator uses the heat content of the incinerator flue gas to heat the incoming VOC-laden stream into the incinerator, thus reducing the thermal energy required in the oxidizer (Eisenmann Corporation). VOC control efficiencies of 99 percent can be achieved through the use of incinerators.

Waterborne, High-solids, and Powder Coatings

Pollution prevention techniques such as use of waterborne coatings, high-solids coatings, and others can be used to reduce VOC emissions. Emissions reductions depend on several variables, such as the amount of VOCs in the original solventborne coating, the amount of VOCs in the replacement coating, relative transfer efficiency of the coatings, and the relative film thickness required. For this reason, emission reductions are difficult to predict, but may range from 60 to 99 percent reduction. The primary disadvantage of using waterborne coatings is that water evaporates slowly, making it difficult to achieve a smooth finish. For this reason, their main use is

as a primer coat. The primary disadvantage of high-solids coatings is that additional mechanical, thermal, or electrical energy may be necessary for pumping and adequate atomization because of the higher viscosity of the coatings.

Waterwash

Particulate emissions from spray booths can be controlled with a water curtain or waterwash filtration system. Coating exhaust air is passed through a water "wall" that traps coating overspray that leads to PM emissions. The spent water is allowed to settle, creating a sludge from the solids, the water is then recirculated through the system. The sludge that is generated must be properly disposed of in accordance with applicable state and local hazardous waste disposal requirements.

2.2 SURFACE COATING SOURCE CATEGORIES

Surface coating operations are an integral part of the manufacturing phase for a variety of materials and products. Major types of surface coating activities are described below and are organized by substrate category. Table 7.2-1 lists point source categories by SIC code that typically have surface coating operations. The information in this table should assist the regulatory agency in point source inventory preparation for these categories. For additional information on surface coating operations and emission estimation guidance, please refer to the *Industrial Surface Coating* chapter within Volume III, *Area Sources Preferred and Alternative Methods*.

Although EPA has minimum requirements for determining whether a source is a point or area source, the state or local agency may have additional requirements, and should therefore, be contacted for ultimate guidance when determining point/area source status of industrial surface coating facilities. EPA procedures for identifying and handling point versus area sources for inventory purposes are described in Volume III, *Introduction to Area Sources Emission Inventory Development* and in the U.S. EPA's *Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone. Volume I: General Guidance for Stationary Sources* (EPA, 1991).

TABLE 7.2-1
STANDARD INDUSTRIAL CLASSIFICATION (SIC) CODES FOR
SURFACE COATING SOURCE CATEGORIES

Source Category	SIC Code	SIC Description
Aircraft Manufacturing	3721	Aircraft
Appliances	363	Household Appliances
Automobiles and Light-duty Trucks	3711	Motor Vehicles and Passenger Car Bodies
	3713	Truck and Bus Bodies
Automobile Refinishing	7532	Top and Body Repair and Paint Shops
Flat Wood Product Manufacturing	2435	Hardwood Veneer and Plywood
	2436	Softwood Veneer and Plywood
Heavy-duty Truck Manufacturing	3531	Construction Machinery
	3537	Industrial Trucks and Tractors
	3713	Truck and Bus Bodies
Magnet Wire	3357	Nonferrous Wiredrawing and Insulating
Metal Cans (Two- or Three-piece)	3411	Metal Cans
Metal Coil	3479	Metal Coil Coating
Metal Furniture	2514	Metal Household Furniture
Miscellaneous Metal Parts	34	Fabricated Metals Products
	35	Industrial Machinery and Equipment
	36	Electronic and Other Electric Equipment
	37	Transportation Equipment
Paper Coating	2671	Paper Coated and Laminated Packaging
Plastic Parts	357	Computer and Office Equipment
Ships	3731	Ship Building and Repairing
Wood Furniture Coating	2434	Wood Kitchen Cabinets
	2511	Wood Household Furniture
	2517	Wood TV and Radio Cabinets
	2521	Wood Office Furniture
	2541	Wood Partitions and Fixtures

For regulatory purposes, state and local agencies may have policies for categorizing surface coating operations, particularly when a process does not obviously fit into a regulated category. The state or local agency, therefore, should be contacted for ultimate guidance when determining applicable regulations.

2.2.1 AIRCRAFT MANUFACTURING

Aircraft manufacturing is defined to be any fabrication, process, or assembly of aircraft parts, or completed unit of any aircraft, including but not limited to airplanes, helicopters, missiles, rockets, and space vehicles.

Surface coating operations used in aircraft manufacturing include the use of spray booths, dip tanks, or the use of enclosed areas, such as a hangars, for the application of one or more coating types (e.g., primer, topcoat) (EPA, 1995a).

Primers are applied to aircraft for corrosion prevention, protection from the environment, functional fluid resistance, and adhesion of subsequent coatings. Topcoatings are applied to aircraft for appearance, identification, camouflage, or protection (California Air Resources Board, 1994).

2.2.2 APPLIANCES

Appliances include metal ranges, ovens, microwave ovens, refrigerators, freezers, washing machines, dryers, dishwashers, water heaters, or trash compactors. Appliance parts are coated for protection or decoration.

Appliance parts are first cleaned with organic degreasers or a caustic detergent (or both) to remove grease and mill scale accumulated during handling. This is often followed by a process to improve the grain of the metal. A phosphate bath is then used to provide corrosion resistance to the appliance surface and to increase the surface area of the part, thereby allowing superior coating adhesion. Often the metal surfaces of the appliance are then coated with a rust inhibitor to prevent rusting prior to painting.

A protective primer coating that also covers surface imperfections and contributes to total coating thickness is then added followed by a final decorative topcoat. Single-coat systems, however, where only a primer coat or topcoat is applied, are becoming more common. For parts not exposed to customer view, a primer coat alone may be used. For exposed parts, a protective coating may be formulated and applied as a topcoat.

There are many different surface coating application techniques in the appliance industry, including manual, automatic, and electrostatic spray operations, and several dipping methods. Selection of a particular method depends mainly upon the geometry and use of the part, the production rate, and the type of coating being used.

A wide variety of coating formulations is used by the appliance industry. The prevalent coating types include epoxies, epoxy/acrylics, acrylics, and polyester enamels. Liquid coatings may use either an organic solvent or water as the main carrier for the paint solids (EPA, 1977b).

2.2.3 AUTOMOBILES AND LIGHT-DUTY TRUCKS

This category includes passenger cars, vans, motorcycles, trucks, farm machinery, construction equipment, and all other mobile equipment that is capable of being driven or drawn upon a highway and is coated during manufacturing and assembly (EPA, 1977c; EPA, 1979). Refinishing of automobiles that occurs subsequent to the original assembly, and includes vehicle repair after accidents, maintenance coating, dock repair of imported automobiles, and dealer repair of transit damage before the sale of an automobile, is a separate source category discussed below.

Surface coating of a newly manufactured automobile body is a multistep operation carried out on an assembly line with an automatic conveyor system. Although finishing processes vary from plant to plant, there are some common characteristics. Major steps in the coating process are primer coating, guide coating, topcoating, and finishing.

Application of coating to the vehicles may take place in a dip tank or spray booth; curing occurs in a bake oven. The application and curing processes are usually contiguous to prevent exposure of the wet body to the ambient environment before the coating is totally cured (EPA, 1979).

Phosphating, primer coat, guide coat, and top coating processes may all be used on the vehicles during manufacturing. Approximately half of all plants use solventborne primers with a combination of manual and automatic spray application. The rest use waterborne primers; however, the use of waterborne primers is expected to increase.

The current trend in the industry is toward base coat/clear coat (BC/CC) topcoating systems, which consist of a relatively thin application of highly pigmented metallic base coat followed by a thicker clear coat. These BC/CC topcoats have a more appealing appearance than do single-coat metallic topcoats, and competitive pressures are expected to increase their use by U.S. manufacturers. The VOC content of most BC/CC coatings in use today, however, is higher than that of conventional enamel topcoats. Development and testing of lower VOC content (higher solids) BC/CC coatings are being done by automobile manufacturers and coating suppliers.

2.2.4 HEAVY-DUTY TRUCK MANUFACTURING

Surface coating of heavy-duty trucks during manufacturing includes many of the operations used in automobile and light-duty trucks. Surface coating operations are divided into the preparation and painting of the cab and the chassis (Turner, 1992).

All of the truck cab assemblies, with the exception of the fiberglass hoods, initially go through a metal finishing line known as the E-coat process, which includes alkaline cleaning and rinsing,

surface treatment using zinc phosphate followed by a chrome rinse for steel and chromic acid for aluminum, rinsing, and then passage through an electrodeposition bath, rinsing and drying. Following E-coating, the cab assemblies go to the undercoating and interior paint line. The exact flow on the line depends on the construction material of the cabs; however, some form of seam-sealing, interior painting, and undercoating is conducted for all of the cabs prior to the main cab painting line. Cab painting generally includes some sanding and painting, and then drying in an oven prior to final assembly. However, the number of sanding, drying, and painting steps will vary depending on the number of colors used on the cab.

Chassis painting is simpler and involves three steps: spot priming, topcoat, and drying prior to final assembly. Assembly incorporates the cabs with the chassis. Due to the custom nature of the manufacturing operation, there is a significant amount of paint touch-up done on all cabs before they leave the facility. The facility also paints some of the individual small parts.

2.2.5 AUTOMOBILE REFINISHING

Automobile refinishing is usually a nonmanufacturing category of surface coating and involves the painting of damaged or worn highway vehicles (EPA, 1994a). Many of the coatings used for newly manufactured vehicles are also used in refinishing operations, with the possible exception of the surface primer coatings. Refinishing operations may be performed in enclosed, partially enclosed, or open areas. Water curtains or filler pads are widely used to control paint particulate emissions; however, they have little or no effect on escaping solvent vapors.

2.2.6 FLAT WOOD PRODUCT MANUFACTURING

Finished flat wood products are interior panels made of hardwood plywoods (natural and lauan), particle board, and hardboard. Fewer than 25 percent of the manufacturers of such flat wood products coat the products in their own plants; in some of the plants that do coat, only a small percentage of total production is coated (EPA, 1995a). At present, most coating is done by toll coaters (which is the industry term for custom coaters) who receive panels from manufacturers and undercoat or finish them according to customer specifications and product requirements.

Some of the layers and coatings that can be factory-applied to flat woods are filler, sealer, groove coat, primer, stain, basecoat, ink, and topcoat. Solvents used in organic flat wood base coatings are usually component mixtures, including methyl ethyl ketone (MEK), methyl isobutyl ketone (MIBK), toluene, xylene, butyl acetates, propanol, ethanol, butanol, naphtha, methanol, amyl acetate, mineral spirits, SoCal[®] I and II, glycols, and glycol ethers. Those most often used in waterborne coatings are glycol, glycol ethers, propanol, and butanol (Turner, 1992).

Various forms of roll coating are the preferred techniques for applying coatings to flat woods. Coatings used for the surface cover can be applied with a direct roller coater; reverse roll coaters are generally used to apply fillers. Precision coating and printing (usually with offset gravure grain printers) are also forms of roll coating. Most inks are pigments dispersed in alkyd resin,

although waterbased inks are available and are desirable because of their clarity, cost, and low environmental impact. Several types of curtain coating may also be employed (usually for topcoat application) with flat wood products. Spray techniques and brush coating may also be used.

Finishing techniques are used to cover the original surface and to produce various decorative effects. Groove coatings, sealers, fillers, and topcoats may be used for this purpose. The coatings may be water- or solvent-based, catalyzed, or UV-cured.

2.2.7 MAGNET WIRE

Magnet wire coating is the process of applying a coating of electrically insulating varnish or enamel to aluminum or copper wire for use in electrical machinery. The wire is called magnet wire because, in equipment such as electrical motors, generators, and transformers, the wire carries an electrical current that creates an electromagnetic field. The wire coating must meet rigid specifications of electrical, thermal, and abrasion resistance.

In a typical wire coating operation, the wire is passed through an annealing furnace that softens the wire and cleans it by burning off oil and dirt. Usually, the wire then passes through a bath in the coating applicator and is drawn through an orifice or coating die to scrape off the excess. It is then dried and cured in a dual temperature zone oven. Wire may pass through the coating applicator and the oven as many as 12 times to acquire the necessary thickness of coating (EPA, 1977d).

2.2.8 METAL CANS (TWO- OR THREE-PIECE)

Cans may be made from a rectangular sheet with two circular ends (three pieces), or they can be drawn and wall ironed from a shallow cup to which an end is attached after the can is filled (two pieces). There are major differences in coating practices, depending on the type of can and the product packaged in it.

Three-piece can coating includes sheet coating with a base coat and printing. When the sheets have been formed into cylinders, the seam is sprayed, usually with a lacquer, to protect the exposed metal. If the cans are to contain an edible product, the interiors are spray coated, and the cans baked at up to 220°C (425°F) (EPA, 1977c).

Two-piece cans are used largely by beer and other beverage industries. The exteriors may be reverse roll coated in white and cured. Several colors of ink are then transferred (sometimes by lithographic printing) to the cans. A protective varnish may be roll coated over the inks. The coating is then cured in a single or multipass oven, recoated, and cured again (EPA, 1977c).

2.2.9 METAL COIL

Metal coil surface coating is a linear process by which protective or decorative organic coatings are applied to metal sheets or strips packaged in rolls or coils (EPA, 1977c). A metal strip is uncoiled at the entry to a coating line and is passed through a wet section, where the metal is thoroughly cleaned and given a chemical treatment to inhibit rust and promote coatings adhesion to the metal surface. In some installations, the wet section contains an electrogalvanizing operation. The metal strip is then dried and sent through a coating application station, where rollers coat one or both sides of the metal strip. The strip then passes through an oven where the coatings are dried and cured. As the strip exits the oven, it is cooled by a water spray and dried again. If it is a tandem line, a prime coat is applied first, followed by another top or finish coat.

The more prevalent coil coating types include polyesters, acrylics, polyfluorocarbons, urethanes, alkyds, vinyls, and plastisols. About 85 percent of the coatings used are organic solvent-based and have solvent contents ranging from near 0 to 80 volume percent, with the prevalent range being 40 to 60 volume percent. Most of the remaining 15 percent of coatings are waterborne, but contain organic solvent in the range of 2 to 15 volume percent. High-solids coatings, in the form of plastisols, organosols, and powders, are also used to some extent by the industry, but the hardware is different for powder applications.

The solvents most often used in the coil coating industry include xylene, toluene, MEK, Cellusolve Acetate™, butanol, diacetone alcohol, Cellusolve™, Butyl Cellusolve™, Solvesso 100™ and 150™, isophorone, butyl carbinol, mineral spirits, ethanol, nitropropane, tetrahydrofuran, Panasolve™, MIBK, Hisol 100™, Tenneco T-125™, isopropanol, and diisoamyl ketone (EPA, 1995a).

Major markets for metal coil coating operations include the transportation industry, the construction industry, and appliance, furniture, and container manufacturers. Many steel and aluminum companies have their own coil coating operations, where the metal they produce is coated and then formed into end products. They are also more likely to use waterborne coatings than toll coaters.

2.2.10 METAL FURNITURE

The metal furniture surface coating process is a multistep operation consisting of surface cleaning, coatings application, and curing. Items such as desks, chairs, tables, cabinets, bookcases, and lockers are normally fabricated from raw material to finished product in the same facility. The industry uses primarily solventborne coatings applied by spray, dip, or flow coating processes. Spray coating is the common application technique used. The components of spray coating lines generally consist of the following: three- to five-stage washer, dryoff oven, spray booth, flashoff area, and bake oven.

The items to be coated are first cleaned and dried. They are then conveyed to the spray booth, where the surface coating is applied, and then through a flashoff area to a bake oven, where the surface coating is cured. Although most metal furniture products receive only one coat of paint,

some facilities apply a prime coat before the topcoat to improve the corrosion resistance of the product. In these cases, a separate spray booth and bake oven for application of the prime coat are added to the line, following the dryoff oven.

The coatings used in the industry are primarily solventborne resins including acrylics, amines, vinyls, and cellulosics. Some metallic coatings are also used on office furniture. The solvents used are mixtures of aliphatics, xylene, toluene, and other aromatics. Typical coatings that have been used in the industry contain 65 volume percent solvent and 35 volume percent solids. Other types of coatings now being used in the industry are waterborne, powder, and solventborne high-solids coatings (EPA, 1977a).

2.2.11 MISCELLANEOUS METAL PARTS

A wide variety of metal parts and products are coated for decorative or protective purposes. These are used by hundreds of small industrial categories that include large farm machinery and small appliances. Some facilities manufacture and coat metal parts and then assemble them to form a final product to be sold directly for retail. Others, often called "job shops," manufacture and coat products under contract with specifications differing from product to product. The metal parts are then shipped to the final product manufacturer to be assembled with other parts into some final product. Such facilities are often located in the vicinity of the manufacturers for whom they perform this service.

The size of each facility is dependent on things such as the number of coating lines, size of parts or products coated, type of coating operation (i.e., spray, dip, flow, or roll coat), and number of coats of paint applied.

The coatings are a critical constituent of the metal parts industry. In many cases, the coatings must provide aesthetic appeal, but in all cases they must protect the metal from the atmosphere in which it will be used. Both enamels and lacquers are used, although enamels are more common. Coatings are often shipped by the manufacturer as a concentrate but thinned prior to application. Alkyds are popular with industrial and farm machinery manufacturers. Most of the coatings contain several different solvents including ketones, esters, alcohols, aliphatics, ethers, aromatics, and terpenes.

Single or double coatings are applied in conveyor or batch operations. Spraying is usually employed for single coats. Flow and dip coating may be used when only one or two colors are applied. For two-coat operations, primers are usually applied by flow or dip coating, and topcoats are almost always applied by spraying. Electrostatic spraying is also common. A manual two-coat operation may be used for large items like industrial and farm machinery. The coatings on large products are often air-dried rather than oven-baked, because the machinery, when completely assembled, includes heat-sensitive materials and may be too large to be cured in an oven. Miscellaneous parts and products can be baked in single- or multipass ovens.

2.2.12 PAPER COATING

Paper is coated for various decorative and functional purposes with waterborne, organic solventborne, or solvent-free extruded materials. Paper coating, not to be confused with printing operations, use contrast coatings that must show a difference in brightness from the paper to be visible. Coating operations are the application of a uniform layer or coating across a substrate; printing, on the other hand, results in an image or design on the substrate.

Waterborne coatings improve printability and gloss but cannot compete with organic solventborne coatings in resistance to weather, scuff, and chemicals. Solventborne coatings, as an added advantage, permit a wide range of surface textures. Most solventborne coating is done by paper-converting companies that buy paper from mills and apply coatings to produce a final product. Among the many products that are coated with solventborne materials are adhesive tapes and labels, decorated paper, book covers, zinc oxide-coated office copier paper, carbon paper, typewriter ribbons, and photographic film (EPA, 1977c).

Organic solvent formulations generally used are made up of film-forming materials, plasticizers, pigments, and solvents. The main classes of film formers used in the paper coating are cellulose derivatives (usually nitrocellulose) and vinyl resins (usually the copolymer of vinyl chloride and vinyl acetate). Three common plasticizers are dioctyl phthalate, tricresyl phosphate, and castor oil. The major solvents used are toluene, xylene, methyl ethyl ketone, isopropyl alcohol, methanol, acetone, and ethanol. Although a single solvent is frequently used, a mixture is often necessary to obtain the optimum drying rate, flexibility, toughness, and abrasion resistance.

A variety of low-solvent coatings, with negligible emissions, have been developed for some uses to form organic resin films equal to those of conventional solventborne coatings. They can be applied up to 1/8-inch thick (usually by reverse roller coating) to products like artificial leather goods, book covers, and carbon paper. Smooth hot-melt finishes can be applied over rough textured paper by heated gravure or roll coaters at temperatures from 65 to 230°C (150 to 450°F).

Plastic extrusion coating is a type of hot-melt coating in which a molten thermoplastic sheet (usually low- or medium-density polyethylene) is extruded from a slotted die at temperatures of up to 315°C (600°F). The substrate and the molten plastic coat are united by pressure between a rubber roll and a chill roll that solidifies the plastic. Many products, such as the polyethylene-coated milk carton, are coated with solvent-free extrusion coatings (EPA, 1977c).

A typical paper coating line that uses organic solventborne formulations usually incorporates a reverse roller, a knife, or a rotogravure printer. Knife coaters can apply solutions of much higher viscosity than roll coaters and thus emit less solvent per pound of solids applied. The gravure printer can print patterns or can coat a solid sheet of color on a paper web (EPA, 1977c; Turner, 1992).

Many paper coatings need to be cured in an oven. Natural gas is the fuel most often used in direct-fired ovens, but fuel oil is used sometimes. Some of the heavier grades of fuel oil can create problems because sulfur oxide (SO) and PM may contaminate the paper coating. Distillate fuel oil usually can be used satisfactorily. Steam produced from burning solvent retrieved from an absorber or vented to an incinerator may also be used to heat curing ovens.

2.2.13 PLASTIC PARTS

Surface coating of plastic parts for business machines is defined as the process of applying coatings to plastic business machine parts to improve the appearance of the parts, to protect the parts from physical or chemical stress, and/or to attenuate electromagnetic interference/radio frequency interference (EMI/RFI) that would otherwise pass through plastic housings (EPA, 1995a). Plastic parts for business machines are synthetic polymers formed into panels, housings, bases, covers, or other business machine components. The business machines category includes items such as typewriters, electronic computing devices, calculating and accounting machines, telephone and telegraph equipment, photocopiers, and miscellaneous office machines.

The process of applying an exterior coating to a plastic part can include surface preparation, spray coating, and curing, with each step possibly being repeated several times. Surface preparation may involve merely wiping off the surface, or it could involve sanding and puttying to smooth the surface. The plastic parts are placed on racks or trays, or are hung on racks or hooks from an overhead conveyor track for transport among spray booths, flashoff areas, and ovens. Coatings are sprayed onto parts in partially enclosed booths. An induced air flow is maintained through the booths to remove overspray and to keep solvent concentrations in the room air at safe levels. Although low-temperature bake ovens (60°C or less [140°F]) are often used to speed up the curing process, coatings may also be partially or completely cured at room temperature.

2.2.14 SHIPS

This category includes surface coating operations at shipbuilding and ship repair facilities. Due to the size and limited accessibility of ships, most shipyard painting operations are performed outdoors. When painting and/or repairs are needed below the water line of a ship, it must be removed from the water using a floating dry dock, graving dock, or marine railway. In new construction operations, assembly is usually modular, and painting is done in several stages at various locations throughout the shipyard. There are five general areas of ship structures that have special coating requirements: antennas and superstructures (including freeboard), exterior deck areas, interior habitability areas, tanks (fuel, water, ballast, and cargo), and underwater hulls (EPA, 1994b).

Marine coatings are vital for protecting the ship from corrosive and biotic attacks from the ship's environment. Many marine paints serve specific functions such as corrosion protection, heat/fire resistance, and antifouling. Marine coatings are usually applied as a "system." A typical coating system comprises a primer coat, an intermediate coat, and a topcoat. The primer is usually a zinc-

rich material that will provide galvanic corrosion protection if the overlying paint system is damaged but would quickly be consumed by sacrificial corrosion without a protective topcoat (EPA, 1994b).

2.2.15 WOOD FURNITURE COATING

The wood furniture industry encompasses the manufacture of many diverse products, such as wood kitchen cabinets; wood residential furniture; upholstered residential and office furniture; wood television, radio, phonograph, and sewing machine cabinets; wood office furniture and fixtures; and partitions, shelving, and lockers. There may also be other wood furniture not described by one of the above categories.

Despite the broad range of products manufactured by this source category, some manufacturing operations are common. There are four basic wood furniture manufacturing operations: finishing, gluing, cleaning, and washoff. Only finishing is considered a coating operation (Code of Federal Regulations [CFR], 1994).

Wood furniture finishing operations include those in which a finishing material is applied to a substrate. The types of finishing materials include stains, base coats, wash coats, glazes, fillers, sealers, highlights, enamels, and topcoats that all serve different functions. The number, sequence, and type of finishing materials varies by the type and quality of the furniture being finished. All of the finishing materials may contain hazardous air pollutants (HAPs) that are emitted during application.

After the finishing material is applied, the wood substrate typically enters a flashoff area where the more volatile solvents evaporate and the finishing material begins to cure. Then the material enters an oven where curing of the finishing material and evaporation of the volatile solvents continues.

Facilities may finish the furniture in components and then assemble it, but more commonly, the piece of furniture is assembled and then finished. The furniture or furniture components may be moved manually from one finishing application station to the next or on tow lines that automatically move through the finishing lines. Finished furniture that does not meet specification may need to be refinished; the cured coating is removed by washing off the old coating using solvent. This process is called washoff.

3

OVERVIEW OF AVAILABLE METHODS

3.1 EMISSION ESTIMATION METHODS

Several methods are available for calculating emissions from surface coating operations. The best method to use depends upon available data, available resources, and the degree of accuracy required in the estimate. In general, site-specific data that are representative of normal operations at that site are preferred over industry-average data such as *AP-42* emission factors.

This section discusses the methods available for calculating emissions from surface coating operations and identifies the preferred method of calculation on a pollutant basis. Although preferred methods are identified, this document does not mandate any emission estimation method. Industry personnel using this manual should contact the appropriate State or local air pollution control agency regarding suggested methods prior to their use. A comparison of the methods is also presented in this section.

3.1.1 MATERIAL BALANCE

Material balance utilizes the raw material usage rate to estimate the amount of pollutant emitted. Other information relating to material usage, such as fraction of the pollutant in the raw material and the amount of material recycled, disposed, or converted to another form, is also included in a material balance calculation. Material balance is used most often where a relatively consistent amount of material is emitted during use, and/or all air emissions are fugitive. The material balance emission rate is calculated by multiplying the raw material used times the amount of pollutant in the coating, and subtracting the amount of pollutant recycled, disposed, or converted to another form. For VOC-containing materials, the amount of pollutant emitted is often assumed to be 100 percent of the amount of pollutant contained in the material unless a control device is used to remove or destroy VOC in the exhaust stream. To estimate VOC emissions from vented operations where a VOC control device is present, it is necessary to estimate the control efficiency of the capture (exhaust) system and the control device. (Note, though, that VOC control devices are not frequently employed for Surface Coating Operations.)

The material balance method may also be used to calculate PM/PM₁₀ emissions if an engineering judgement is made regarding the transfer efficiency of the application equipment and the control efficiency of any PM/PM₁₀ control devices (for vented operations). These data are used in conjunction with the manufacturer's data or calculated solids content of the coating to estimate PM/PM₁₀ emissions.

3.1.2 SOURCE SAMPLING

Source sampling provides a "snapshot" of emissions during the period of the test. Air samples are taken from the exhaust vent of a coating area (e.g., spray booth or totally enclosed and vented coating operation) and passed into canisters or through various filter media on which the pollutants are captured. The canisters or filters are sent to a laboratory for analysis. Pollutant concentrations are obtained by dividing the amount of pollutant collected during the test by the sample gas volume. Emission rates are determined by multiplying the pollutant concentration by the vent gas exhaust rate. A modification of this technique can be used for open surface coating areas that are temporarily enclosed for sampling purposes and vented through a stack. The calculation of emission rates for this situation is more complicated than for permanently enclosed areas and involves some assumptions about the conditions in the source area.

Source sampling methods can be used to measure VOC, HAP (organic and inorganic), and PM/PM₁₀ emissions.

3.1.3 PREDICTIVE EMISSION MONITORING (PEM)

Predictive emission monitoring (PEM) is based on developing a correlation between pollutant emission rates and an easily measured process parameter. The most accurate PEM data will result from using source sampling results. These data can be correlated with surface coating operation parameters, such as coating usage rates, pieces of equipment coated, or time. The most appropriate data are obtained from, and defined for, specific surface coating operations (e.g., applying topcoats) and for specific industries (e.g., furniture manufacturing). The more specific the emissions data are to the operation to be inventoried, the more appropriate and accurate the PEM data will be for the intended use.

PEM data are usually presented as emissions curves, where the x-axis is a source parameter, such as coating usage or time, and the y-axis is emissions. For data that form a straight line, the PEM data can be expressed as an emission factor that is equal to the slope of the emissions curve. For example, if the slope of a PEM curve is 20 pounds VOCs emitted per 100 pounds of surface coating used, this factor can be multiplied times the amount of surface coating used on a daily, weekly, monthly, or annual basis to estimate the amount of VOCs emitted. This is true only if the coating usage is consistent during the test data process and is representative of other time periods.

Periodic sampling may be required to verify that the emission curves are still accurate or to develop new curves to represent changes in source operation.

3.1.4 EMISSION FACTORS

An emission factor is a pollutant emission rate relative to a source activity (e.g., pound of VOCs emitted per gallon of surface coating applied). Emission factors are available for some surface coating operations and are based on the results of source tests or material balances performed for one or more facilities within an industry. Chapter 1, *Introduction to Point Source Emission Inventory Development*, contains a detailed discussion of the reliability and quality of available emission factors. The EPA provides compiled emission factors for criteria and hazardous air pollutants in AP-42, the *Locating and Estimating Emissions of . . .* (L&E) series of documents, and the Factor Information Retrieval (FIRE) System (EPA, 1995b).

Due to their availability and acceptance, emission factors are commonly used to prepare emission inventories. However, the emissions estimate obtained from using emission factors is likely to be based upon emission testing performed at similar but not identical facilities and may not accurately reflect emissions at a single source. Thus, the user should recognize that, in most cases, emission factors are averages of available industry-wide data with varying degrees of quality and uncertainty, and may not be representative for an individual facility within that industry. Average emission factors based on solvent or coating used are generally more accurate than emission factors based on parts or area painted.

Source-specific emission factors can be developed from multiple source test data, PEM data, or from single source tests. These emission factors, when used for the specific operations for which they are intended, are generally more representative than the average emission factors found in AP-42 or FIRE (EPA, 1995a and 1995b). However, VOC emissions from uncontrolled surface coating operations are usually best estimated by assuming that all solvent in the coating will be emitted.

3.2 COMPARISON OF AVAILABLE EMISSION ESTIMATION METHODOLOGIES

Tables 7.3-1 and 7.3-2 identify the preferred and alternative emission estimation approaches for selected pollutants, for vented coating operations and open coating operations, respectively. For many of the pollutants emitted from surface coating operations, several of the previously defined emission estimation methodologies can be used.

TABLE 7.3-1

**SUMMARY OF PREFERRED AND ALTERNATIVE EMISSION
ESTIMATION METHODS FOR SURFACE COATING OPERATIONS:
VENTED COATING OPERATIONS^a**

Parameter	Preferred Emission Estimation Approach^b	Alternative Emission Estimation Approach
VOC	Material Balance	Source Testing PEM Emission Factor
Speciated Organics (HAPs)	Material Balance	Source Testing PEM Emission Factor
PM/PM ₁₀	Source Testing	Material Balance PEM Emission Factor

^a Vented coating operations include those operations that are vented to the atmosphere or to a control device either directly or through the use of a capture/collection system.

^b Where there is a choice of methods, material balance is generally preferred over an emission factor unless the assumptions needed to perform a material balance (e.g., estimate of fugitive flashoff) have a high degree of uncertainty and/or the emission factor is site-specific.

The preferred method for estimating VOC emissions from both vented and open surface coating operations is material balance. The preferred method for estimating PM/PM₁₀ emissions from vented coating operations is source testing and from open coating operations is material balance. Source testing or PEM methods may provide accurate emission estimates, but the quality of the data will depend on a variety of factors including the number of data points generated, the representativeness of those data points, and the proper operation and maintenance of the equipment being used to record the measurements. With PEM, care must be taken to ascertain that the data capture represents typical surface coating operating conditions for the source. Otherwise, the PEM data should not be used to estimate annual emissions or any time period much longer than the PEM sampling period. Additionally, source testing and PEM data are often difficult and costly to obtain for surface coating operations.

For a detailed discussion of statistical measures of uncertainty and data quality, refer to the volume on *Quality Assurance Procedures* (Volume VI, Chapters 3 and 4).

TABLE 7.3-2

**SUMMARY OF PREFERRED AND ALTERNATIVE EMISSION
ESTIMATION METHODS FOR SURFACE COATING OPERATIONS:
OPEN COATING OPERATIONS^a**

Parameter	Preferred Emission Estimation Approach^b	Alternative Emission Estimation Approach
VOC	Material Balance	PEM Emission Factor Source Testing
Speciated Organics (HAPs)	Material Balance	PEM Emission Factor Source Testing
PM/PM ₁₀	Material Balance	PEM Emission Factor Source Testing

^a Open coating operations include those operations that are open to the atmosphere or nonvented operations.

^b Where there is a choice of methods, material balance is generally preferred over an emission factor unless the assumptions needed to perform a material balance (e.g., estimate of fugitive flashoff) have a high degree of uncertainty and/or the emission factor is site-specific.

This page is intentionally left blank.

4

PREFERRED METHODS FOR ESTIMATING EMISSIONS

The preferred method for estimating VOC and speciated organic emissions from all surface coating operations is the use of a material balance. This approach can be used to estimate VOC and speciated VOC emissions from vented coating operations as well as open coating operations. Material balance is also the preferred method for estimating PM/PM₁₀ emissions from open coating operations. Material balance uses the raw material usage rate to estimate the amount of pollutant emitted.

The preferred method for estimating PM/PM₁₀ emissions from vented coating operations is source testing. Source testing uses sampling results to estimate PM/PM₁₀ and the respective component emissions.

As discussed in this document, vented coating operations include those surface coating operations that vent to pollution control equipment or the atmosphere either directly or through the use of some capture/collection equipment. Open coating operations are those operations that are not vented to a pollution control device or the atmosphere either directly or through the use of some capture/collection device. For material balance calculations, total emissions can be separated into captured and fugitive emissions. Captured emissions are typically exhausted directly to the atmosphere or to pollution control equipment and then to the atmosphere and are, therefore, typically point source emissions. Fugitive emissions are those emissions not captured and vented to a pollution control equipment or directly to the atmosphere. For open coating operations, all emissions will be fugitive; therefore, for these operations, total emissions will equal fugitive emissions.

The following equations and examples present how to use a material balance or source testing approach to estimate total VOC, PM/PM₁₀, and speciated emissions from vented or open coating operations. Table 7.4-1 lists the variables and symbols used in the following discussions.

TABLE 7.4-1**LIST OF VARIABLES AND SYMBOLS**

Variable	Symbol	Units
Total VOC emissions	E_{VOC}	lb/hr or ton/yr
Captured VOC emissions	$E_{\text{VOC},p}$	lb/hr or ton/yr
Fugitive VOC emissions	$E_{\text{VOC},f}$	lb/hr or ton/yr
Material usage rate	Q	typically gal/hr or gal/yr
VOC content of material	C_{VOC}	lb/gal
Capture efficiency	Cap	%
Fraction of solvent volatilized	F	fraction
Density of material used	d	lb/gal
Weight percentage of pollutant x in material	$\text{wt}\%_x$	%
Speciated emissions of pollutant x	E_x	lb/hr or lb/yr
Speciated captured emissions of pollutant x	$E_{x,p}$	lb/hr or lb/yr
Speciated fugitive emissions of pollutant x	$E_{x,f}$	lb/hr or lb/yr
Total material usage rate of multiple-part coating	Q_T	gal/hr or gal/yr
Number of parts of component i in multiple-part coating	N_i	dimensionless
Total number of components in multiple-part coating	n	dimensionless
PM/PM ₁₀ emissions	E_{PM}	lb/hr or ton/yr
PM/PM ₁₀ or solids content of material	C_{PM}	lb/gal
Transfer efficiency of application equipment	T.E.	%
Stack gas concentration of pollutant x	C_x	grains per dry standard cubic feet (dscf)
Stack gas volumetric flow rate	V	dry standard cubic feet per minute (dscfm)
Annual emissions of pollutant x	A_x	ton/yr
Operating hours	OH	hr/yr

4.1 CALCULATION OF VOC EMISSIONS USING MATERIAL BALANCE (VENTED AND OPEN COATING OPERATIONS)

Material balance can be used to estimate VOC emissions from all surface coating operations. Total emissions include both captured (point source) and fugitive losses. Calculate total VOC emissions using Equation 7.4-1.

$$E_{\text{VOC}} = Q * C_{\text{VOC}} \quad (7.4-1)$$

where:

$$\begin{aligned} E_{\text{VOC}} &= \text{Total VOC emissions (lb/hr) (captured and fugitive)} \\ Q &= \text{Material usage rate (gal/hr)} \\ C_{\text{VOC}} &= \text{VOC content of material (lb/gal)} \end{aligned}$$

The VOC content of the material (C_{VOC}) can be obtained through the manufacturer's technical specification sheet or EPA Reference Method 24 may be used to determine VOC content. The VOC content should account for solvent or other material added to the coating.

Captured and fugitive emissions can be calculated separately. Use Equation 7.4-2 to calculate captured emissions:

$$E_{\text{VOC,p}} = E_{\text{VOC}} * \text{Cap}/100 * F \quad (7.4-2)$$

where:

$$\begin{aligned} E_{\text{VOC,p}} &= \text{Captured VOC emissions (lb/hr)} \\ E_{\text{VOC}} &= \text{Total VOC emissions (lb/hr)} \\ \text{Cap} &= \text{Capture efficiency (\%)} \\ F &= \text{Fraction of solvent volatilized at this step in the coating process (e.g., application area, drying area)} \end{aligned}$$

Capture efficiency (Cap) is typically a design parameter that can be determined by reviewing equipment specifications or by contacting the equipment manufacturer. Equipment such as hoods, spray booths, and totally enclosed processes typically have a capture efficiency. Open coating operations are nonvented operations and, therefore, have no capture efficiency.

The fraction of solvent volatilized at any particular step in a coating process (F) can be estimated using available resources. Table 7.4-2 presents a distribution of VOC emissions for selected coating industries. Coating manufacturers may also be able to provide solvent evaporation curves that can be used to distribute solvent losses. Reference books may also provide solvent evaporation curves. In cases where the coating application and drying steps are vented to the same capture system, the variable F in Equation 7.4-2 equals 1. Example 7.4-1 illustrates the use of solvent evaporation curves to distribute VOC emissions from a coating operation.

In a material balance calculation, all unaccounted for VOCs can be assumed to be fugitive emissions. Use Equation 7.4-3 to estimate fugitive emissions based on a material balance:

$$E_{\text{VOC},f} = E_{\text{VOC}} - E_{\text{VOC},p} \quad (7.4-3)$$

where:

$E_{\text{VOC},f}$ = Fugitive VOC emissions (lb/hr)

E_{VOC} = Total VOC emissions (lb/hr)

$E_{\text{VOC},p}$ = Captured VOC emissions (lb/hr)

For open coating operations, the captured emission component ($E_{\text{VOC},p}$) of Equation 7.4-3 is zero, therefore, fugitive VOC emissions ($E_{\text{VOC},f}$) are equal to total VOC emissions (E_{VOC}).

Total annual VOC emissions can be calculated using material balance by applying annual rather than hourly material usage rates in Equation 7.4-1.

Examples 7.4-2 through 7.4-4 illustrate the use of Equations 7.4-1 through 7.4-3 to calculate both hourly and annual total, captured, and fugitive emissions. These examples also illustrate the conversion of annual emissions from lb/yr to ton/yr.

TABLE 7.4-2

**DISTRIBUTION OF VOC EMISSIONS EMITTED DURING SURFACE
COATING OPERATIONS FOR SELECTED INDUSTRIES**

Coating Industry	Percentage of Total VOC Emissions	
	Spray Booth or Application Area and Flashoff	Bake Oven
Metal furniture	70	30
Automobile and light-duty truck	85 - 90	10 - 15
Large appliance	80	20
Coil coating ^a	8	90

^a Remaining VOC emissions (2%) come from the quench section after the bake/curing oven.

Source: Air Pollution Engineering Manual (Turner, 1992)

Example 7.4-1

This example calculates the solvent distribution fraction for a coating process in which parts are coated in a spray booth and moved to a drying oven given the following data:

Time in spray booth = 10 minutes
Time to transport to drying oven = 20 minutes
Type of coating = acrylic

According to Figure 655 from Modern Pollution Control Technology (an attachment to the 1993 Texas Air Control Board guideline package [see Section 8, References for complete citation]), after 10 minutes, approximately 45 percent of the solvent in an acrylic coating will volatilize. After another 20 minutes, another 7 percent of the solvent will volatilize. The remaining 48 percent of the solvent will volatilize in the oven. Based on this figure, the solvent volatilization fraction (F) that should be used to estimate emissions from each step in this coating process is:

F = 0.45 (spray booth)
 = 0.07 (transport to drying oven)
 = 0.48 (drying oven)

Example 7.4-2

This example shows how hourly and annual VOC emissions for a coating operation where both coating and drying occur under a laboratory hood can be calculated using Equations 7.4-1 through 7.4-3. The data are given below.

Given:

$$\begin{aligned} Q &= 10 \text{ gal/hr} \\ &= 1,000 \text{ gal/yr} \\ C_{\text{VOC}} &= 7 \text{ lb/gal} \\ F &= 1 \\ \text{Cap} &= 60\% \end{aligned}$$

Total VOC emissions from coating and drying are calculated using Equation 7.4-1:

$$\begin{aligned} E_{\text{VOC}} &= Q * C_{\text{VOC}} \\ &= 10 \text{ gal/hr} * 7 \text{ lb/gal} \\ &= 70 \text{ lb/hr} \end{aligned} \quad (7.4-1)$$

Hourly captured VOC emissions from coating and drying are calculated using Equation 7.4-2:

$$\begin{aligned} E_{\text{VOC,p}} &= E_{\text{VOC}} * \text{Cap}/100 * F \\ &= 70 \text{ lb/hr} * 60/100 * 1 \\ &= 42 \text{ lb/hr} \end{aligned} \quad (7.4-2)$$

Fugitive hourly VOC emissions from coating and drying are calculated using Equation 7.4-3:

$$\begin{aligned} E_{\text{VOC,f}} &= E_{\text{VOC}} - E_{\text{VOC,p}} \\ &= 70 \text{ lb/hr} - 42 \text{ lb/hr} \\ &= 28 \text{ lb/hr} \end{aligned} \quad (7.4-3)$$

Total annual VOC emissions from coating and drying are calculated using Equation 7.4-1 using annual material usage rates:

$$\begin{aligned} E_{\text{VOC}} &= Q * C_{\text{VOC}} \\ &= 1,000 \text{ gal/yr} * 7 \text{ lb/gal} \\ &= 7,000 \text{ lb/yr} * (1 \text{ ton}/2,000 \text{ lb}) \\ &= 3.5 \text{ ton/yr} \end{aligned} \quad (7.4-1)$$

Annual captured VOC emissions from coating and drying are calculated using Equation 7.4-2:

$$\begin{aligned} E_{\text{VOC,p}} &= E_{\text{VOC}} * \text{Cap}/100 * F \\ &= 3.5 \text{ ton/yr} * 60/100 * 1 \\ &= 2.1 \text{ ton/yr} \end{aligned} \quad (7.4-2)$$

Annual fugitive VOC emissions from coating and drying are calculated using Equation 7.4-3:

$$\begin{aligned} E_{\text{VOC,f}} &= E_{\text{VOC}} - E_{\text{VOC,p}} \\ &= 3.5 \text{ ton/yr} - 2.1 \text{ ton/yr} \\ &= 1.4 \text{ ton/yr} \end{aligned} \quad (7.4-3)$$

Example 7.4-3

This example shows how hourly and annual VOC emissions from a spray booth coating operation for which products are air dried outside the booth can be calculated using Equations 7.4-1 through 7.4-3 and the data given below.

Given:

$$\begin{aligned}
 Q &= 25 \text{ gal/hr} \\
 &= 85,000 \text{ gal/yr} \\
 C_{\text{VOC}} &= 7 \text{ lb/gal} \\
 F &= 0.65 \text{ (spray booth)} \\
 &= 0.35 \text{ (air drying)} \\
 \text{Cap} &= 80\% \text{ (spray booth)} \\
 &= 0\% \text{ (air drying)}
 \end{aligned}$$

Total VOC emissions from the spray booth and air drying are calculated using Equation 7.4-1:

$$\begin{aligned}
 E_{\text{VOC}} &= Q * C_{\text{VOC}} \\
 &= 25 \text{ gal/hr} * 7 \text{ lb/gal} \\
 &= 175 \text{ lb/hr}
 \end{aligned} \tag{7.4-1}$$

Hourly captured VOC emissions from the spray booth are calculated using Equation 7.4-2:

$$\begin{aligned}
 E_{\text{VOC,p}} &= E_{\text{VOC}} * \text{Cap}/100 * F \\
 &= 175 \text{ lb/hr} * 80/100 * 0.65 \\
 &= 91 \text{ lb/hr}
 \end{aligned} \tag{7.4-2}$$

Because the emissions from the air drying step are not vented, the capture efficiency (Cap) is 0 percent, and the emissions from air drying are all fugitive emissions.

Fugitive hourly VOC emissions from the spray booth and air drying are calculated using Equation 7.4-3:

$$\begin{aligned}
 E_{\text{VOC,f}} &= E_{\text{VOC}} - E_{\text{VOC,p}} \\
 &= 175 \text{ lb/hr} - 91 \text{ lb/hr} \\
 &= 84 \text{ lb/hr}
 \end{aligned} \tag{7.4-3}$$

Total annual VOC emissions from the spray booth and air drying are calculated with Equation 7.4-1 using annual material usage rates:

$$\begin{aligned}
 E_{\text{VOC}} &= Q * C_{\text{VOC}} \\
 &= 85,000 \text{ gal/yr} * 7 \text{ lb/gal} \\
 &= 595,000 \text{ lb/yr} * (1 \text{ ton}/2,000 \text{ lb}) \\
 &= 298 \text{ ton/yr}
 \end{aligned} \tag{7.4-1}$$

Annual captured VOC emissions from the spray booth are calculated using Equation 7.4-2:

$$\begin{aligned}
 E_{\text{VOC,p}} &= E_{\text{VOC}} * \text{Cap}/100 * F \\
 &= 298 \text{ ton/yr} * 80/100 * 0.65 \\
 &= 155 \text{ ton/yr}
 \end{aligned} \tag{7.4-2}$$

Example 7.4-3 (Continued)

Because the emissions from the air drying step are not vented, the capture efficiency (Cap) is 0 percent and the emissions from air drying are all fugitive emissions.

Annual fugitive VOC emissions from the spray booth and air drying are calculated using Equation 7.4-3:

$$\begin{aligned} E_{\text{VOC},f} &= E_{\text{VOC}} - E_{\text{VOC},p} \\ &= 298 \text{ ton/yr} - 155 \text{ ton/yr} \\ &= 143 \text{ ton/yr} \end{aligned} \quad (7.4-3)$$

Example 7.4-4

This example shows how hourly and annual VOC emissions from a coating operation for which products are air dried outside the booth can be calculated using Equations 7.4-1 through 7.4-3 and the data given below.

Given:

$$\begin{aligned} Q &= 18 \text{ gal/hr} \\ &= 28,500 \text{ gal/yr} \\ C_{\text{VOC}} &= 7.6 \text{ lb/gal} \\ F &= 0.40 \text{ (coating)} \\ &= 0.20 \text{ (transport to dryer)} \\ &= 0.40 \text{ (drying)} \\ \text{Cap} &= 60\% \text{ (coating)} \\ &= 0\% \text{ (transport to dryer)} \\ &= 100\% \text{ (drying)} \end{aligned}$$

Total VOC emissions from all steps are calculated using Equation 7.4-1:

$$\begin{aligned} E_{\text{VOC}} &= Q * C_{\text{VOC}} \\ &= 18 \text{ gal/hr} * 7.6 \text{ lb/gal} \\ &= 136.8 \text{ lb/hr} \end{aligned} \quad (7.4-1)$$

Hourly captured VOC emissions from coating and drying are calculated using Equation 7.4-2:

$$\begin{aligned} E_{\text{VOC},p} &= E_{\text{VOC}} * \text{Cap}/100 * F \\ \text{Coating} &= 136.8 \text{ lb/hr} * 60/100 * 0.40 \\ &= 32.8 \text{ lb/hr} \\ \text{Drying} &= 136.8 \text{ lb/hr} * 100/100 * 0.40 \\ &= 54.7 \text{ lb/hr} \end{aligned} \quad (7.4-2)$$

Because the emissions from the transport to dryer step are not vented, the capture efficiency (Cap) is 0 percent, and the emissions from transport are all fugitive emissions.

Example 7.4-4 (Continued)

Fugitive hourly VOC emissions from all steps are calculated using Equation 7.4-3:

$$\begin{aligned} E_{\text{VOC},f} &= E_{\text{VOC}} - E_{\text{VOC},p} \\ &= 136.8 \text{ lb/hr} - (32.8 \text{ lb/hr} + 54.7 \text{ lb/hr}) \\ &= 49.3 \text{ lb/hr} \end{aligned} \quad (7.4-3)$$

Total annual VOC emissions from all steps are calculated with Equation 7.4-1 using annual material usage rates:

$$\begin{aligned} E_{\text{VOC}} &= Q * C_{\text{VOC}} \\ &= 28,500 \text{ gal/yr} * 7.6 \text{ lb/gal} \\ &= 216,600 \text{ lb/yr} * (1 \text{ ton}/2,000 \text{ lb}) \\ &= 108 \text{ ton/yr} \end{aligned} \quad (7.4-1)$$

Annual captured VOC emissions from coating and drying are calculated using Equation 7.4-2:

$$\begin{aligned} E_{\text{VOC},p} &= E_{\text{VOC}} * \text{Cap}/100 * F \\ \text{Coating} &= 108 \text{ ton/yr} * 40/100 * 0.40 \\ &= 17.3 \text{ ton/yr} \\ \text{Drying} &= 108 \text{ ton/yr} * 100/100 * 0.40 \\ &= 43.2 \text{ ton/yr} \end{aligned} \quad (7.4-2)$$

Because the emissions from the transport to dryer step are not vented, the capture efficiency (Cap) is 0 percent and the emissions from transport are all fugitive emissions.

Annual fugitive VOC emissions from all steps are calculated using Equation 7.4-3:

$$\begin{aligned} E_{\text{VOC},f} &= E_{\text{VOC}} - E_{\text{VOC},p} \\ &= 108 \text{ ton/yr} - (17.3 \text{ ton/yr} + 43.2 \text{ ton/yr}) \\ &= 47.5 \text{ ton/yr} \end{aligned} \quad (7.4-3)$$

4.2 CALCULATION OF SPECIATED VOC EMISSIONS USING MATERIAL BALANCE

Material balance can also be used to calculate speciated VOC emissions. Each VOC species emission rate can be determined using Equation 7.4-4:

$$E_x = Q * d * \frac{\text{wt}\%_x}{100} \quad (7.4-4)$$

where:

E_x	=	Emissions of VOC species "x" (lb/hr)
Q	=	Material usage rate (gal/hr)
d	=	Density of the material used (lb/gal)
$wt\%_x$	=	Weight percent of pollutant "x" in material (%)

The density (d) and the weight percent of pollutant "x" ($wt\%_x$) can be obtained from the manufacturer's technical specification sheet. The weight percent of pollutant "x" should consider any solvent or other material added to the coating.

The captured and fugitive emissions of VOC species "x" can be estimated using the total VOC species "x" emissions calculated above and Equations 7.4-5 and 7.4-6.

Use Equation 7.4-5 to calculate captured emissions:

$$E_{x,p} = E_x * Cap / 100 * F \quad (7.4-5)$$

where:

$E_{x,p}$	=	Captured emissions of pollutant x (lb/hr)
E_x	=	Total pollutant x emissions (lb/hr)
Cap	=	Capture efficiency (%)
F	=	Fraction of solvent volatilized at this step in the coating process (e.g., application area, drying area)

Capture efficiency (Cap) is typically a design parameter that can be determined by reviewing equipment specifications or by contacting the equipment manufacturer. Equipment such as hoods, spray booths, and totally enclosed processes typically have a capture efficiency. Open coating operations are nonvented operations and, therefore, have no capture efficiency.

The fraction of solvent volatilized at any particular step in a coating process (F) can be estimated using available resources. Table 7.4-2 presents a distribution of emissions for selected coating industries. Coating manufacturers may also be able to provide solvent evaporation curves that can be used to distribute solvent losses. Reference books may also provide solvent evaporation curves. In cases where the coating application and drying steps are vented to the same capture system, the variable F in Equation 7.4-2 equals 1. Example 7.4-1 illustrates the use of solvent evaporation curves to distribute emissions from a coating operation.

In a material balance calculation, all unaccounted for emissions can be assumed to be fugitive emissions. Use Equation 7.4-6 to estimate fugitive emissions based on a material balance:

$$E_{x,f} = E_x - E_{x,p} \quad (7.4-6)$$

where:

$E_{x,f}$	=	Fugitive emissions of pollutant x (lb/hr)
E_x	=	Total pollutant x emissions (lb/hr)
$E_{x,p}$	=	Captured emissions of pollutant x (lb/hr)

For open coating operations, the captured emission component ($E_{x,p}$) of Equation 7.4-6 is zero, therefore, fugitive emissions ($E_{x,f}$) are equal to total pollutant x emissions (E_x).

Annual speciated emissions can be calculated by applying an annual rather than an hourly material usage rate in Equation 7.4-4.

Example 7.4-5 illustrates the use of Equations 7.4-4 through 7.4-6 to calculate both hourly and annual total, captured, and fugitive VOC species emissions.

4.3 CALCULATION OF EMISSIONS FOR MULTIPLE-PART COATINGS

Some coatings require the addition of a thinning solvent, a catalyst, or both resulting in a multiple-part coating. Material usage rates for these coatings must be determined for each part (the thinner, the catalyst, and the coating) based on the mixing ratio of the parts.

Example 7.4-5

This example shows how hourly and annual VOC speciated emissions from a spray booth coating operation for which products are air dried outside the booth can be calculated using Equations 7.4-4 through 7.4-6 and the data given below. Emissions from only one species ("x") are shown, as an example, however, typically more than one VOC species will be present and the following calculations would have to be completed for each species.

Given:

$$\begin{aligned}
 Q &= 10 \text{ gal/hr} \\
 &= 5,200 \text{ gal/yr} \\
 \text{wt\%}_x &= 38\% \\
 d &= 10 \text{ lb/gal} \\
 F &= 0.65 \text{ (spray booth)} \\
 &= 0.35 \text{ (air drying)} \\
 \text{Cap} &= 80\% \text{ (spray booth)} \\
 &= 0\% \text{ (air drying)}
 \end{aligned}$$

Calculate total hourly pollutant x emissions from the spray booth and air drying using Equation 7.4-4:

$$\begin{aligned}
 E_x &= Q * d * \text{wt\%}_x / 100 \\
 &= 10 \text{ gal/hr} * 10 \text{ lb/gal} * 38 / 100 \\
 &= 38 \text{ lb/hr}
 \end{aligned} \tag{7.4-4}$$

Hourly captured pollutant x emissions from the spray booth are calculated using Equation 7.4-5:

$$\begin{aligned}
 E_{x,p} &= E_x * \text{cap} / 100 * F \\
 &= 38 \text{ lb/hr} * 80 / 100 * 0.65 \\
 &= 19.76 \text{ lb/hr}
 \end{aligned} \tag{7.4-5}$$

Because the emissions from the air drying step are not vented, the capture efficiency (Cap) is 0 percent, and there are no captured emissions from air drying.

Hourly fugitive emissions of pollutant x from the spray booth and air drying are calculated using Equation 7.4-6:

$$\begin{aligned}
 E_{x,f} &= E_x - E_{x,p} \\
 &= 38 \text{ lb/hr} - 19.76 \text{ lb/hr} \\
 &= 18.24 \text{ lb/hr}
 \end{aligned} \tag{7.4-6}$$

Total annual pollutant x emissions from the spray booth and air drying are calculated using Equation 7.4-4:

$$\begin{aligned}
 E_x &= Q * d * \text{wt\%}_x / 100 \\
 &= 5,200 \text{ gal/yr} * 10 \text{ lb/gal} * 38 / 100 \\
 &= 19,760 \text{ lb/yr}
 \end{aligned} \tag{7.4-4}$$

Annual captured emissions of pollutant x from the spray booth are calculated using Equation 7.4-5:

$$\begin{aligned}
 E_{x,p} &= E_x * \text{Cap} / 100 * F \\
 &= 19,760 \text{ lb/yr} * 80 / 100 * 0.65 \\
 &= 10,275 \text{ lb/yr}
 \end{aligned} \tag{7.4-5}$$

Example 7.4-5 (Continued)

Because the emissions from the air drying step are not vented, the capture efficiency (Cap) is 0 percent, and there are no captured emissions from air drying.

Annual fugitive pollutant x emissions from the spray booth and air drying are calculated using Equation 7.4-6:

$$\begin{aligned} E_{x,f} &= E_x * E_{x,p} \\ &= 19,760 \text{ lb/yr} * 10,275 \text{ lb/yr} \end{aligned} \quad (7.4-6)$$

The material usage rate for each part of a multiple-part coating can be calculated using mixing ratios and algebra, with Equation 7.4-7:

$$Q = Q_T * \frac{N_i}{\sum_{i=1}^n N_i} \quad (7.4-7)$$

where:

- Q = Material usage rate (gal/hr) of component (e.g., coating, thinner)
- Q_T = Total multiple-part coating material usage rate (gal/hr)
- N_i = Number of parts of component i in multiple-part coating
- n = Total number of components in multiple-part coating

For example, for a two-component coating with a thinner-to-coating mixing ratio of 1:6 (i.e., 1 part thinner to 6 parts coating), Equation 7.4-7 would be represented as:

For the thinner:

$$Q = Q_T * \frac{1}{1+6}$$

For the coating:

$$Q = Q_T * \frac{6}{1+6}$$

The material usage rates calculated for each component should be used in Equations 7.4-1 through 7.4-6 to estimate total, fugitive, and captured emissions from each component in the multiple-part coating. Examples 7.4-6 and 7.4-7 illustrate the use of Equation 7.4-7 to estimate emissions from two-component coatings.

When a multiple-part coating contains more than two components (e.g., coating, thinner, and catalyst), application of Equation 7.4-7 may require an iterative process depending on the known mixing ratio(s). For example, if the known mixing ratio is 1 part catalyst, 2 parts thinner, and 8 parts coating, no iterative process is required and the material usage rate of each component could be calculated directly from Equation 7.4-7 ($n=3$). If, however, there are two mixing ratios (2 parts thinner to 8 parts catalyzed coating and 1 part catalyst to 8 parts coating), an iterative process would be required. The material usage rates for the thinner and catalyzed coating would be calculated first using Equation 7.4-7. The catalyzed coating usage rate calculated would then be factored back into Equation 7.4-7 along with the catalyst-to-coating mixing ratio (2:8) to estimate the usage rates of the catalyst and the coating. Example 7.4-8 illustrates this iterative process.

4.4 CALCULATION OF PM/PM₁₀ EMISSIONS USING MATERIAL BALANCE (OPEN COATING OPERATIONS)

The preferred method for estimating PM/PM₁₀ emissions from open coating operations is material balance. Hourly PM/PM₁₀ emissions are calculated by material balance using Equation 7.4-8:

$$E_{PM} = Q * C_{PM} * (1 - T.E./100) \quad (7.4-8)$$

where:

- E_{PM} = PM/PM₁₀ emissions (lb/hr)
- Q = Material usage rate (gal/hr)
- C_{PM} = PM/PM₁₀ or solids content of material (lb/gal)
- $T.E.$ = Transfer efficiency of the application equipment (%)

The PM/PM₁₀ content of the material (C_{PM}) can be determined from the manufacturer's technical specification sheet. The transfer efficiency for a particular product and application technique can be obtained from the application equipment manufacturer or from technical references such as *AP-42* (EPA, 1995a).

Annual PM/PM₁₀ emissions are calculated by using an annual rather than an hourly usage rate in Equation 7.4-8 and converting to ton/yr.

Example 7.4-6

Calculate emissions for thinner and coating given the following data:

Mixing ratio = 1:6 thinner to coating (i.e., 1 part thinner to 6 parts coating)

Q_T = 50 gal/hr

C_{voc} = 7 lb/gal (thinner)

= 2.3 lb/gal (coating)

1. Calculate usage rate for each component using the mixing ratio and Equation 7.4-7:

$$Q = Q_T * N_i / (\sum_{i=1}^n N_i) \quad (7.4-7)$$

A. Thinner, Q = 50 gal/hr * 1/(1+6)
= 7.14 gal/hr

B. Coating, Q = 50 gal/hr * 6/(1+6)
= 42.86 gal/hr

2. Calculate VOC emissions for thinner using Equation 7.4-1:

Q = 7.14 gal/hr

C_{voc} = 7 lb/gal

E_{voc} = $Q * C_{voc}$ (7.4-1)
= 7.14 gal/hr * 7 lb/gal
= 50 lb/hr

3. Calculate VOC emissions for coating using Equation 7.4-1:

Q = 42.86 gal/hr

C_{voc} = 2.3 lb/gal

E_{voc} = $Q * C_{voc}$ (7.4-1)
= 42.86 gal/hr * 2.3 lb/gal
= 99 lb/hr

Note: Solvents common to the thinner and coating should be summed. For example, if both the coating and thinner contain methyl ethyl ketone (MEK), then total MEK should be summed.

Example 7.4-7

Calculate emissions from a catalyzed coating given the following data:

Mixing ratio = 1:8 catalyst to coating (i.e., 1 part catalyst to 8 parts coating)
 Q_T = 50 gal/hr
 C_{VOC} = 5.2 lb/gal (catalyst)
 = 2.3 lb/gal (coating)

1. Calculate usage rate per component using Equation 7.4-7:

$$Q = Q_T * N_i / (\sum_{i=1}^n N_i) \quad (7.4-7)$$

A. Catalyst, Q = 50 gal/hr * 1/(1+8)
 = 5.6 gal/hr

B. Coating, Q = 50 gal/hr * 8/(1+8)
 = 44.4 gal/hr

2. Calculate VOC emissions for a catalyst using Equation 7.4-1:

$$\begin{aligned} Q &= 5.6 \text{ gal/hr} \\ C_{VOC} &= 5.2 \text{ lb/gal} \\ E_{VOC} &= Q * C_{VOC} \\ &= 5.6 \text{ gal/hr} * 5.2 \text{ lb/gal} \\ &= 29 \text{ lb/hr} \end{aligned} \quad (7.4-1)$$

3. Calculate VOC emissions for a coating using Equation 7.4-1:

$$\begin{aligned} Q &= 44.4 \text{ gal/hr} \\ C_{VOC} &= 2.3 \text{ lb/gal} \\ E_{VOC} &= Q * C_{VOC} \\ &= 44.4 \text{ gal/hr} * 2.3 \text{ lb/gal} \\ &= 102 \text{ lb/hr} \end{aligned} \quad (7.4-1)$$

Example 7.4-8

Calculate emissions from a thinned and catalyzed coating given the following data:

Mixing ratios:

2:8 thinner to catalyzed coating (i.e., 2 parts thinner to 8 parts catalyzed coating)

1:8 catalyst to coating (i.e., 1 part catalyst to 8 parts coating)

C_{voc} = 7 lb/gal (thinner)
 = 5.2 lb/gal (catalyst)
 = 2.3 lb/gal (coating)

Annual usage of the multiple-part coating = 50,000 gal/yr ($Q_T = 50,000$ gal/yr)

1. Calculate usage rate per component using Equation 7.4-7:

$$Q = Q_T * N_i / (\sum_{i=1}^n N_i) \quad (7.4-7)$$

- A. Calculate usage rate for thinner and catalyzed coating:

Thinner, Q = 50,000 gal/yr * 2/(2+8)
 = 10,000 gal/yr

Catalyzed coating, Q = 50,000 gal/yr * 8/(2+8)
 = 40,000 gal/yr

- B. Calculate usage rate for catalyst and coating based on total usage rate of catalyzed coating calculated above ($Q_T = 40,000$ gal/yr):

Catalyst, Q = 40,000 gal/yr * 1/(1+8)
 = 4,444 gal/yr

Coating, Q = 40,000 gal/yr * 8/(1+8)
 = 35,556 gal/yr

2. Calculate VOC emissions from thinner, catalyst, and coating using Equation 7.4-1 and the usage rates per part calculated above:

$$E_{\text{voc}} = Q * C_{\text{voc}} \quad (7.4-1)$$

C_{voc} = 7 lb/gal (thinner)
 = 5.2 lb/gal (catalyst)
 = 2.3 lb/gal (coating)

Example 7.4-8 (Continued)

- A. Thinner, $E_{\text{VOC}} = 10,000 \text{ gal/yr} * 7 \text{ lb/gal}$
 $= 70,000 \text{ lb/yr}$
- B. Catalyst, $E_{\text{VOC}} = 4,444 \text{ gal/yr} * 5.2 \text{ lb/gal}$
 $= 23,000 \text{ lb/yr}$
- C. Coating, $E_{\text{VOC}} = 35,556 \text{ gal/yr} * 2.3 \text{ lb/gal}$
 $= 82,000 \text{ lb/yr}$

Example 7.4-9 shows the use of Equation 7.4-8 to calculate both hourly and annual PM/PM₁₀ emissions. Example 7.4-9 also illustrates the conversion of annual emissions from lb/yr to ton/yr.

Hourly speciated PM/PM₁₀ emissions are calculated using Equation 7.4-9:

$$E_x = Q * d * \frac{\text{wt}\%_x}{100} * (1 - \text{T.E.}/100) \quad (7.4-9)$$

where:

- E_x = Emissions of PM/PM₁₀ species x (lb/hr)
 Q = Material usage rate (gal/hr)
 d = Density of the material used (lb/gal)
 $\text{wt}\%_x$ = Weight percent of the PM/PM₁₀ species x (%)
 T.E. = Transfer efficiency of the application equipment (%)

The weight percent of the PM/PM₁₀ species x ($\text{wt}\%_x$) can be determined from the manufacturer's technical specification sheet. The transfer efficiency for a particular product and application technique can be obtained from the application equipment manufacturer or from technical references such as AP-42 (EPA, 1995a).

Example 7.4-10 shows how speciated PM/PM₁₀ emissions can be calculated using Equation 7.4-9.

Example 7.4-9

This example shows how hourly and annual PM/PM₁₀ emissions can be calculated using Equation 7.4-8 and the data given below:

Given:

$$\begin{aligned} Q &= 10.0 \text{ gal/hr} \\ &= 3,250 \text{ gal/yr} \\ \text{T.E.} &= 45\% \\ C_{\text{PM}} &= 3.0 \text{ lb/gal} \end{aligned}$$

Hourly PM/PM₁₀ emissions are calculated using Equation 7.4-8:

$$\begin{aligned} E_{\text{PM}} &= Q * C_{\text{PM}} * (1 - \text{T.E.}/100) \\ &= 10.0 \text{ gal/hr} * 3.0 \text{ lb/gal} * (1 - 45/100) \\ &= 16.5 \text{ lb/hr} \end{aligned} \quad (7.4-8)$$

Annual PM/PM₁₀ emissions are calculated using annual usage rates and Equation 7.4-8:

$$\begin{aligned} E_{\text{PM}} &= Q * C_{\text{PM}} * (1 - \text{T.E.}/100) \\ &= 3,250 \text{ gal/yr} * 3.0 \text{ lb/gal} * (1 - 45/100) \\ &= 5,360 \text{ lb/yr} * \text{ton}/2,000 \text{ lb} \\ &= 2.68 \text{ ton/yr} \end{aligned} \quad (7.4-8)$$

4.5 CALCULATION OF PM/PM₁₀ EMISSIONS USING SOURCE TESTING DATA (VENTED COATING OPERATIONS)

The preferred method for estimating PM/PM₁₀ emissions from vented coating operations is stack sampling (e.g., EPA Reference Method 5 and Method 201). The methodology described in Chapter 2 of this series, *Preferred and Alternative Methods for Estimating Air Emissions from Boilers*, Section 4, "Estimating PM₁₀ Emissions using Raw Stack Sampling Data" shows how PM₁₀ emissions can be calculated using EPA Method 201.

Stack sampling test reports often provide particulate concentration data in grains per dry standard cubic feet (grain/dscf). An hourly emission rate can be determined based on this stack gas concentration using Equation 7.4-10:

$$E_x = (C_x * V * 60)/7,000 \quad (7.4-10)$$

where:

$$\begin{aligned} E_x &= \text{Speciated emissions of pollutant x (lb/hr)} \\ C_x &= \text{Stack gas concentration of pollutant x (grain/dscf)} \\ V &= \text{Stack gas volumetric flow rate (dscfm)} \\ 60 &= 60 \text{ min/hr} \\ 7,000 &= 7,000 \text{ grain/lb} \end{aligned}$$

Example 7.4-10

This example shows how to estimate hourly and annual PM/PM₁₀ species x emissions using Equation 7.4-9 and the data given below:

Given:

$$\begin{aligned} Q &= 10 \text{ gal/hr} \\ &= 23,000 \text{ gal/yr} \\ d &= 8.32 \text{ lb/gal} \\ \text{T.E.} &= 45\% \\ \text{wt}\%_x &= 15\% \end{aligned}$$

Calculate the hourly emissions of PM/PM₁₀ species x using Equation 7.4-9:

$$\begin{aligned} E_x &= Q * d * \text{wt}\%_x / 100 * (1 - \text{T.E.}/100) \\ &= 10 \text{ gal/hr} * 8.32 \text{ lb/gal} * 15/100 * (1 - 45/100) \\ &= 6.9 \text{ lb/hr} \end{aligned} \quad (7.4-9)$$

Calculate annual emissions for PM/PM₁₀ species x using Equation 7.4-9 and convert to tons per year:

$$\begin{aligned} E_x &= Q * d * \text{wt}\%_x / 100 * (1 - \text{T.E.}/100) \\ &= 23,000 \text{ gal/yr} * 8.32 \text{ lb/gal} * 15/100 * (1 - 45/100) \\ &= 15,800 \text{ lb/yr} * 1 \text{ ton}/2,000 \text{ lb} \\ &= 7.9 \text{ ton/yr} \end{aligned} \quad (7.4-9)$$

Emissions in tons per year can be calculated by multiplying the average hourly emission rate (lb/hr) from Equation 7.4-10 by the number of operating hours (as in Equation 7.4-11 below).

$$A_x = E_x * \text{OH} * 1 \text{ ton}/2,000 \text{ lb} \quad (7.4-11)$$

where:

$$\begin{aligned} A_x &= \text{Annual emissions of pollutant x (ton/yr)} \\ E_x &= \text{Speciated hourly emissions of pollutant x (lb/hr)} \\ \text{OH} &= \text{Operating hours (hr/yr)} \end{aligned}$$

Example 7.4-11 illustrates the use of stack test data to estimate PM/PM₁₀ emissions. This example also illustrates the conversion from lb/yr to ton/yr.

Example 7.4-11

This example shows how hourly and annual PM/PM₁₀ emissions can be calculated using the data obtained from a stack test. The PM/PM₁₀ concentration based on stack test results is 0.015 grain/dscf. Hourly emissions are calculated using Equation 7.4-10, and annual emissions are calculated using Equation 7.4-11.

Given:

$$\begin{aligned}C_x &= 0.015 \text{ grain/dscf} \\V &= 1,817 \text{ dscfm} \\OH &= 1,760 \text{ hr/yr}\end{aligned}$$

Hourly emissions are calculated using Equation 7.4-10:

$$\begin{aligned}E_x &= (C_x * V * 60)/7,000 & (7.4-10) \\&= \frac{0.015 \text{ grain/dscf} * 1,817 \text{ dscf/min} * 60 \text{ min/hr}}{7,000 \text{ grain/lb}} \\&= 0.23 \text{ lb/hr}\end{aligned}$$

Annual emissions are calculated using Equation 7.4-11:

$$\begin{aligned}A_x &= E_x * OH * 1 \text{ ton}/2,000 \text{ lb} & (7.4-11) \\&= 0.23 \text{ lb/hr} * 1,760 \text{ hr/yr} * 1 \text{ ton}/2,000 \text{ lb}\end{aligned}$$

This page is intentionally left blank.

5

ALTERNATIVE METHODS FOR ESTIMATING EMISSIONS

For open coating operations, PEM, emission factors, and source testing are the alternative methods for estimating VOC, PM/PM₁₀, and HAP emissions. For vented coating operations, source testing, PEM, and emission factors are the alternative methods for estimating VOC and HAP emissions, and material balance, emission factors, and PEM are the alternative methods for estimating PM/PM₁₀ emissions.

Table 7.5-1 lists the variables and symbols used in the following discussions.

5.1 PREDICTIVE EMISSION MONITORING (PEM)

PEM is a predictive emission estimation method where emissions are correlated to process parameters based on demonstrated correlations. PEM develops a correlation between pollutant emissions and an easily measured process parameter. Amount of material used, the number of items coated, and hours of operation are quantifiable parameters that affect emissions and can be used to develop a correlation with emissions. When developing a PEM correlation, parameter data and corresponding emissions are collected for several tests. Table 7.5-2 illustrates data and emissions that can be used to develop a correlation.

5.2 EMISSION FACTOR CALCULATIONS

Emission factors can be used when site-specific monitoring data are unavailable. The EPA maintains *AP-42*, a compilation of approved emission factors for criteria pollutants and HAPs (EPA, 1995a). Another comprehensive source of available air pollutant emission factors from numerous sources is the FIRE system (EPA, 1995b).

Much work has been done recently on developing emission factors for HAPs and recent *AP-42* revisions have included these factors (EPA, 1995a). In addition, many states have developed their own HAP emission factors for certain source categories and may require their use in any inventories that include HAPs. Refer to Chapter 1, *Introduction to Point Source Emission Inventory Development*, of this series for a complete discussion of available information sources for locating, developing, and using emission factors as an estimation technique.

TABLE 7.5-1**LIST OF VARIABLES AND SYMBOLS**

Variable	Symbol	Units
Emissions of pollutant x	E_x	typically lb/hr of pollutant x
Activity factor	AF	gal/hr, for example
Emission factor for pollutant x	EF_x	typically lb/gal of pollutant x
Density of material	d	lb/gal
Concentration of pollutant x at the source	C_x	parts per million volume dry (ppmvd)
Temperature correction for differences in temperature during test	K_t	dimensionless
Pressure correction for differences in pressure during test	K_p	dimensionless
Average concentration of pollutant x	$C_{a,x}$	ppmvd
Molecular weight of pollutant x	MW_x	lb/lb-mole of pollutant x
Molar volume	M	cubic feet (ft ³)/lb-mole
Stack gas volumetric flow rate	V	dry standard cubic feet per minute (dscfm)
Annual emissions of pollutant x	A_x	ton/yr
Operating hours	OH	hr/yr
PM/PM ₁₀ emissions	E_{PM}	lb/hr
Material usage rate	Q	typically gal/hr or gal/yr
PM/PM ₁₀ or solids content of material	C_{PM}	lb/gal
Transfer efficiency of application equipment	T.E.	%
Weight percentage of pollutant x in material	wt% _x	%

TABLE 7.5-2**PREDICTIVE EMISSION MONITORING ANALYSIS^a**

Test Number	Amount of Material Used (gal)	No. of Items Coated	Hours of Operation	Emissions (lb)
1	20	5	2	40
2	35	7	3	70
3	10	3	1	22
4	8	3	1	16
5	22	5	2	43
6	20	5	2	42
7	10	3	1	21
8	30	7	3	62
9	18	5	2	35

^a Data for this example may be used to develop a correlation between emissions and process parameters.

In this example, the PEM correlation could be in terms of lb/gal, lb/item coated, or lb/hr.

Emission factors developed from measurements for a specific spray booth, dip tank, or open area may sometimes be used to estimate emissions at other sites. For example, a company may have several spray booths of a similar model and size that conduct a similar coating process; if emissions were measured from one spray booth, a factor can be developed and applied to the other spray booths. It is advisable to have the factor approved by state/local agencies or by the EPA before using it to calculate emissions.

The basic equation used to calculate emissions using an emission factor is shown in Equation 7.5-1:

$$E_x = EF_x * AF \quad (7.5-1)$$

where:

E_x = Emissions of pollutant "x"

EF_x = Emission factor of pollutant x

AF = Activity factor

Example 7.5-1 shows how VOC and PM₁₀ emissions may be calculated for an industrial surface coating operation using an emission factor.

Example 7.5-1

This example shows how VOC and PM₁₀ emissions may be calculated for an uncontrolled industrial surface coating operation using a conventional enamel paint with a density (d) of 7.6 lb/gal and a VOC content of 45 percent by weight (wt%_{VOC}). Assume that for this operation the paint usage rate or activity factor (AF) is 10 gal/hr. From AP-42, Table 4.2.2.1-1, for conventional paints, an emission factor is developed as follows:

$$\begin{aligned} EF_{VOC} &= d * wt\%_{VOC}/100 \\ &= (7.6 \text{ lb/gal}) * 45 \text{ lb VOC}/100 \text{ lb coating} \\ &= 3.42 \text{ lb VOC/gal coating} \end{aligned}$$

Thus,

$$\begin{aligned} E_{VOC} &= EF_{VOC} * AF \\ &= 3.42 \text{ lb VOC/gal coating} * 10 \text{ gal coating/hr} \\ &= 34.2 \text{ lb VOC/hr} \end{aligned} \tag{7.5-1}$$

Using above information and the FIRE emission factor of 6.4 lb PM₁₀/ton of solvent in the coating (assume that the solvent content equals the VOC content):

$$\begin{aligned} EF_{PM10} &= (6.4 \text{ lb PM}_{10}/\text{ton VOC}) * (3.42 \text{ lb VOC/gal coating}) * (1 \text{ ton}/2,000 \text{ lb}) \\ &= 0.0109 \text{ lb PM}_{10}/\text{gal coating} \end{aligned}$$

Thus,

$$\begin{aligned} E_{PM10} &= EF_{PM10} * AF \\ &= (0.0109 \text{ lb PM}_{10}/\text{gal coating}) * 10 \text{ gal coating/hr} \\ &= 0.109 \text{ lb PM}_{10}/\text{hr} \end{aligned}$$

5.3 EMISSIONS CALCULATIONS USING SOURCE TESTING DATA

Various stack sampling test methods can be used to estimate VOC emissions and speciated organic emission rates from surface coating operations (e.g., EPA Method 25). Air flow rates can be determined from flow rate meters or from pressure drops across a critical orifice (e.g., EPA Reference Method 2).

Stack sampling test reports often provide chemical concentration data in parts per million by volume dry (ppmvd). For gaseous pollutants, the concentration of a pollutant (C_x) can be determined from the Equation 7.5-2:

$$C_x = K_t * K_p * C_{a,x} \quad (7.5-2)$$

where:

- C_x = Concentration of pollutant x (ppmvd) at the source
- K_t = Temperature correction for differences in temperature during test
- K_p = Pressure correction for differences in pressure during test
- $C_{a,x}$ = Average concentration of pollutant x for all analyzed samples (ppmvd)

If the concentration is known, an hourly emission rate can be determined using Equation 7.5-3:

$$E_x = (C_x * MW_x * V * 60) / (M * 10^6) \quad (7.5-3)$$

where:

- E_x = Hourly emissions of pollutant x (lb/hr)
- C_x = Concentration of pollutant x (ppmvd)
- MW_x = Molecular weight of pollutant x (lb/lb-mole)
- V = Stack gas volumetric flow rate (dscfm)
- 60 = 60 min/hr
- M = Volume occupied by 1 mole of ideal gas at standard temperature and pressure (385.5 ft³/lb-mole at 68°F and 1 atm)

Emissions in tons per year can be calculated by multiplying the average hourly emission rate (lb/hr) from Equation 7.5-3 by the number of operating hours (as in Equation 7.5-4 below) or by multiplying an average emission factor (lb/gal) by the total annual amount of material used (gal).

$$A_x = E_x * OH * 1 \text{ ton}/2,000 \text{ lb} \quad (7.5-4)$$

where:

- A_x = Annual emissions of pollutant x (ton/yr)
- E_x = Hourly emissions of pollutant x (lb/hr)
- OH = Operating hours (hr/yr)

Example 7.5-2 illustrates the use of Equations 7.5-2 through 7.5-4.

Example 7.5-2

This example shows how annual VOC emissions can be calculated using the data obtained from a stack test. The concentration of pollutant x is calculated using Equation 7.5-2, hourly emissions are calculated using Equation 7.5-3, and annual emissions are calculated using Equation 7.5-4.

Given:

$$\begin{aligned}K_t &= 1.0 \\K_p &= 0.8 \\C_{a,x} &= 15.4 \text{ ppmvd} \\MW_x &= 12.0 \text{ lb/lb-mole} \\V &= 1,817 \text{ dscfm} \\OH &= 1,760 \text{ hr/yr}\end{aligned}$$

The concentration of pollutant x is calculated using Equation 7.5-2:

$$\begin{aligned}C_x &= K_t * K_p * C_{a,x} \\&= 1.0 * 0.8 * 15.4 \\&= 12.32 \text{ ppmvd}\end{aligned} \tag{7.5-2}$$

Hourly emissions are calculated using Equation 7.5-3:

$$\begin{aligned}E_x &= (C_x * MW_x * V * 60) / (M * 10^6) \\&= 12.3 * 12.0 * 1,817 * 60 / (385.5 * 10^6) \\&= 0.0418 \text{ lb/hr}\end{aligned} \tag{7.5-3}$$

Annual emissions are calculated using Equation 7.5-4:

$$\begin{aligned}A_x &= E_x * OH * 1 \text{ ton/2,000 lb} \\&= 0.0418 * (1,760/2,000) \\&= 0.0368 \text{ ton/yr}\end{aligned} \tag{7.5-4}$$

5.4 CALCULATION OF PM/PM₁₀ EMISSIONS FROM VENTED COATING OPERATIONS USING MATERIAL BALANCE

Hourly controlled PM/PM₁₀ emissions are calculated by material balance using Equation 7.5-5:

$$E_{PM} = Q * C_{PM} * (1 - T.E./100) * (1 - F.E./100) \tag{7.5-5}$$

where:

$$\begin{aligned}E_{PM} &= \text{PM/PM}_{10} \text{ emissions (lb/hr)} \\Q &= \text{Material usage rate (gal/hr)} \\C_{PM} &= \text{PM/PM}_{10} \text{ or solids content of material (lb/gal)}\end{aligned}$$

T.E. = Transfer efficiency of the application equipment (%)

F.E. = Filter efficiency of the PM/PM₁₀ control equipment (%)

The PM/PM₁₀ content of the material (C_{PM}) can be determined from the manufacturer's technical specification sheet. The transfer efficiency for a particular product and application technique can be obtained from the application equipment manufacturer or from technical references such as AP-42 (EPA, 1995a).

Control efficiencies (which can be acquired from the equipment vendor or manufacturer) for PM/PM₁₀ control devices are frequently in excess of 90% for PM, but there can be considerable variation in the control efficiency for PM₁₀. It is important to make sure that an appropriate filter efficiency is used for calculating emissions (i.e., do not assume that a device's PM₁₀ filter efficiency is identical to its PM filter efficiency).

If detailed filter efficiencies are not available, additional guidance is available in documents such as EPA's Fractional Penetration of Paint Overspray Arrestors (EPA-600/R-97-011, May 1997).

Note that the use of Equation 7.5-5 assumes that 100% of the PM/PM₁₀ emissions are vented through the control device (i.e., that there are no fugitive emissions).

Annual PM/PM₁₀ emissions are calculated by using an annual rather than an hourly usage rate in Equation 7.5-5 and converting to ton/yr.

Example 7.5-3 shows the use of Equation 7.5-5 to calculate both controlled hourly and annual PM/PM₁₀ emissions. Example 7.5-3 also illustrates the conversion of annual emissions from lb/yr to ton/yr.

Example 7.5-3

This example shows how hourly and annual PM/PM₁₀ emissions can be calculated using Equation 7.5-5 and the data given below:

Given:

$$\begin{aligned} Q &= 10.0 \text{ gal/hr} \\ &= 3,250 \text{ gal/yr} \\ \text{T.E.} &= 45\% \\ C_{\text{PM}} &= 3.0 \text{ lb/gal} \\ \text{F.E.} &= 99\% \end{aligned}$$

Hourly PM/PM₁₀ emissions are calculated using Equation 7.5-5:

$$\begin{aligned} E_{\text{PM}} &= Q * C_{\text{PM}} * (1 - \text{T.E.}/100) * (1 - \text{F.E.}/100) \\ &= 10.0 \text{ gal/hr} * 3.0 \text{ lb/gal} * (1 - 45/100) * (1 - 99/100) \\ &= 0.165 \text{ lb/hr} \end{aligned} \quad (7.5-5)$$

Annual PM/PM₁₀ emissions are calculated using annual usage rates and Equation 7.5-5:

$$\begin{aligned} E_{\text{PM}} &= Q * C_{\text{PM}} * (1 - \text{T.E.}/100) * (1 - \text{F.E.}/100) \\ &= 3,250 \text{ gal/yr} * 3.0 \text{ lb/gal} * (1 - 99/100) \\ &= 53.6 \text{ lb/yr} * \text{ton}/2,000 \text{ lb} \\ &= 0.027 \text{ ton/yr} \end{aligned} \quad (7.5-5)$$

Hourly uncontrolled speciated PM/PM₁₀ emissions are calculated using Equation 7.5-6:

$$E_x = Q * d * \frac{\text{wt}\%_x}{100} * (1 - \text{T.E.}/100) \quad (7.5-6)$$

where:

$$\begin{aligned} E_x &= \text{Emissions of PM/PM}_{10} \text{ species } x \text{ (lb/hr)} \\ Q &= \text{Material usage rate (gal/hr)} \\ d &= \text{Density of the material used (lb/gal)} \\ \text{wt}\%_x &= \text{Weight percent of the PM/PM}_{10} \text{ species } x \text{ (\%)} \\ \text{T.E.} &= \text{Transfer efficiency of the application equipment (\%)} \end{aligned}$$

The weight percent of the PM/PM₁₀ species x (wt%_x) can be determined from the manufacturer's technical specification sheet. The transfer efficiency for a particular product and application

technique can be obtained from the application equipment manufacturer or from technical references such as *AP-42* (EPA, 1995a).

Example 7.5-4

This example shows how to estimate hourly and annual PM/PM₁₀ species x emissions using Equation 7.5-6.

Given:

$$\begin{aligned} Q &= 10 \text{ gal/hr} \\ &= 23,000 \text{ gal/yr} \\ d &= 8.32 \text{ lb/gal} \\ \text{T.E.} &= 45\% \\ \text{wt}\%_x &= 15\% \end{aligned}$$

Calculate the hourly emissions of PM/PM₁₀ species x using Equation 7.5-6:

$$\begin{aligned} E_x &= Q * d * \text{wt}\%_x / 100 * (1 - \text{T.E.}/100) \\ &= 10 \text{ gal/hr} * 8.32 \text{ lb/gal} * 15/100 * (1 - 45/100) \\ &= 6.9 \text{ lb/hr} \end{aligned} \tag{7.5-6}$$

Calculate annual emissions for PM/PM₁₀ species x using Equation 7.5-6 and convert to tons per year:

$$\begin{aligned} E_x &= Q * d * \text{wt}\%_x / 100 * (1 - \text{T.E.}/100) \\ &= 23,000 \text{ gal/yr} * 8.32 \text{ lb/gal} * 15/100 * (1 - 45/100) \\ &= 15,800 \text{ lb/yr} * 1 \text{ ton}/2,000 \text{ lb} \\ &= 7.9 \text{ ton/yr} \end{aligned} \tag{7.5-6}$$

Example 7.5-4 shows how speciated PM/PM₁₀ emissions can be calculated using Equation 7.5-6.

This page is intentionally left blank.

6

QUALITY ASSURANCE/QUALITY CONTROL

The consistent use of standardized methods and procedures is essential in the compilation of reliable emission inventories. Quality assurance (QA) and quality control (QC) of an inventory is accomplished through a set of procedures that ensure the quality and reliability of data collection and analysis. These procedures include the use of appropriate emission estimation techniques, applicable and reasonable assumptions, accuracy/logic checks of computer models, checks of calculations, and data reliability checks. Figure 7.6-1 provides an example checklist that could aid the preparation of an inventory where surface coating operations must be considered. Volume VI of this series, *Quality Assurance Procedures*, describes additional QA/QC methods and tools for performing these procedures.

Volume II, Chapter 1, *Introduction to Point Source Emission Inventory Development*, presents recommended standard procedures to follow to ensure that the reported inventory data are complete and accurate. Chapter 1 discusses preparation of a QA plan, development and use of QC checklists, and QA/QC procedures for specific emission estimation methods (e.g., emission factors).

6.1 GENERAL QA/QC CONSIDERATIONS INVOLVED IN EMISSION ESTIMATION TECHNIQUES

6.1.1 MATERIAL BALANCE

The accuracy and reliability of emission values calculated using the material balance approach are related to the quality of material usage and speciation data. The quantity of material used in a coating operation is often "eye-balled," a procedure that can easily result in an error of as great as 25 percent. This level of uncertainty can be reduced by using a standardized method of measuring quantities such as a gravimetric procedure (e.g., weighing a container before and after using the material) or use of a stick or gauge to measure the level of liquid in a container. For certain applications (e.g., those where very small quantities of materials are used), it may be more accurate to make these types of measurements monthly or annually, rather than after each application event. Another technique for determining usage quantities would be to use purchase and inventory records.

Item	Y/N	Corrective Action (Complete if "N"; Describe, Sign, and Date)
<p>If the material balance method is being used for emission calculations, have the necessary data been collected, including:</p> <ul style="list-style-type: none"> • Material usage rates; • Fugitive flashoff estimates; • Material speciation data; • Material densities; • Transfer efficiencies of application equipment; and • Filter efficiencies of spray booth filters? 		
If toxic emissions are to be calculated using test data, are the test methods approved?		
If the toxic emissions are to be calculated using emission factors, are the emission factors from AP-42 or FIRE?		
Have stack parameters been provided for each stack or vent that emits criteria or toxic pollutants?		
If required by the state, has a site diagram been included with the emission inventory? This should be a detailed plant drawing showing the location of sources/stacks with ID numbers for all processes, control equipment, and exhaust points.		
Have examples of all calculations been included?		
Have all assumptions been documented?		
Have references for all calculation methods been included?		
Have all conversions and units been reviewed and checked for accuracy?		

FIGURE 7.6-1

EXAMPLE EMISSION INVENTORY CHECKLIST FOR SURFACE COATING OPERATIONS

Uncertainty of emissions using the material balance approach is also related to the quality of material speciation data, which is typically extracted from Technical Specification Sheets. If speciation data are not available on these sheets, the material manufacturer should be contacted.

6.1.2 SOURCE TESTING AND PEM

Data collected via source testing or PEM must meet quality objectives. Source test data must be reviewed to ensure that the test was conducted under normal operating conditions, or under maximum operating conditions in some states, and that the results were generated according to an acceptable method for each pollutant of interest. Calculation and interpretation of accuracy for stack testing methods and PEM are described in detail in the *Quality Assurance Handbook for Air Pollution Measurements Systems: Volume III. Stationary Source Specific Methods (Interim Edition)*.

The acceptance criteria, limits, and values for each control parameter associated with manual sampling methods, such as dry gas meter calibration, are summarized in Chapter 1 of this volume. The magnitudes of concentration and emission rate errors caused by a +10 percent error in various types of measurements (e.g., stack diameter and temperature) are also presented in Chapter 1 of this volume.

6.1.3 EMISSION FACTORS

The use of emission factors is straightforward when the relationship between process data and emissions is direct and relatively uncomplicated. When using emission factors, the user should be aware of the quality indicator associated with the value. Emission factors published within EPA documents and electronic tools have a quality rating applied to them. The lower the quality rating, the more likely that a given emission factor may not be representative of the source type. The reliability and uncertainty of using emission factors as an emission estimation technique are discussed in detail in the QA/QC section of Chapter 1 of this volume.

6.2 DATA ATTRIBUTE RATING SYSTEM (DARS) SCORES

One measure of emission inventory data quality is the DARS score. Four examples are given here to illustrate DARS scoring using the preferred and alternative methods. DARS provides a numerical ranking on a scale of 0 to 1.0 for individual attributes of the emission factor and the activity data. Each score is based on what is known about the factor and the activity data, such as the specificity to the source category and the measurement technique employed. The composite attribute score for the emissions estimate can be viewed as a statement of the confidence that can be placed in the data. For a complete discussion of DARS and other rating systems, see *Quality Assurance Procedures* (Volume VI, Chapter 4) and Volume II, Chapter 1, *Introduction to Point Source Emission Inventory Development*.

Table 7.6-1 gives a set of scores for an estimate based on material balance data. Tables 7.6-2 and 7.6-3 give a set of scores for estimates based on source sampling and PEM data, respectively. Table 7.6-4 gives an example for an estimate prepared with an emission factor.

Each of the examples below is hypothetical. A range is given where appropriate to cover different situations. Maximum scores of 1.0 are automatic for the source specificity and spatial congruity attributes. Likewise, the temporal congruity attribute receives a 1.0 if data capture is greater than 90 percent; this assumes that data are sampled adequately throughout the year. The measurement/method attribute score of 1.0 assumes that the pollutants of interest were measured directly. A lower score is given if the emissions are speciated using a profile or if the emissions are used as a surrogate for another pollutant. Also, the measurement/method score can be less than 1.0 if the relative accuracy is poor (e.g., >10 percent), if the data are biased, or if data capture is closer to 90 percent than to 100 percent.

These examples are given as an illustration of the relative quality of each method. If the sample analysis was done for a real site, the scores could be different but the relative ranking of methods should stay the same. Note, however, that if the source is not truly a member of the population used to develop the EPA correlation equations or the emission factors, these approaches are less appropriate and the DARS scores will probably drop.

If sufficient data are available, the uncertainty in the estimate should be evaluated. Qualitative and quantitative methods for conducting uncertainty analyses are described in *Quality Assurance Procedures* (Volume VI, Chapter 4).

TABLE 7.6-1
DARS SCORES: MATERIAL BALANCE

Attribute	Factor Score	Activity Score	Emissions Score	Factor Assumptions	Activity Assumptions
Measurement/ Method	0.50	0.90 - 1.0	0.45 - 0.5	Based on material balance, all/most end-points accounted for.	Lower scores reflects direct, intermittent measurement of activity; upper score reflects direct, continuous measurement of activity.
Source Specificity	1.0	1.0	1.0	Factor is developed specifically for the intended source.	Activity data represents the emission process exactly.
Spatial Congruity	1.0	1.0	1.0	Factor is developed for and specific to the given spatial scale.	Activity data are developed for and specific to the inventory.
Temporal Congruity	1.0	1.0	1.0	Factor is developed for and is applicable to the temporal period represented in inventory	Activity data are specific for the temporal period represented in the inventory.
Composite Scores	0.88	0.98	0.86 - 0.88		

TABLE 7.6-2
DARS SCORES: SOURCE SAMPLING

Attribute	Factor Score	Activity Score	Emissions Score	Factor Assumptions	Activity Assumptions
Measurement/ Method	0.70 - 0.90	0.80	0.56 - 0.72	Lower score reflects a small number of tests at typical loads; upper score represents numerous tests over a range of loads.	Activity rate is derived from a surrogate that is indirectly related to the activity data (rather than a surrogate that has been directly related and measured).
Source Specificity	1.0	1.0	1.0	Factor is developed specifically for the intended source.	Activity data represents the emission process exactly.
Spatial Congruity	1.0	1.0	1.0	Factor is developed for and is specific to the given spatial scale.	Activity data is developed for and specific to the inventory.
Temporal Congruity	0.70 - 1.0	0.70 - 1.0	0.49 - 1.0	Lower score reflects a factor developed for a shorter time period with moderate to low temporal variability; upper score reflects a factor developed for an applicable to the same temporal scale.	Lower score reflects activity data representative of a short period of time; upper score represents activity data specific for the temporal period represented in the inventory.
Composite Scores	0.85 - 0.98	0.88 - 0.95	0.76 - 0.93		

TABLE 7.6-3

DARS SCORES: PREDICTIVE EMISSIONS MONITORING (PEM)

Attribute	Factor Score	Activity Score	Emissions Score	Factor Assumptions	Activity Assumptions
Measurement/ Method	0.50	0.10	0.50	The factor is based on study data representative of the process.	Activity data are a direct continuous measurement of the activity of the source.
Source Specificity	1.0	0.90	0.90	The factor is developed specifically for the intended source.	Activity is very closely correlated to the emissions activity.
Spatial Congruity	1.0	1.0	1.0	The factor is developed for and specific to the given spatial scale.	Activity data are developed for and specific to the inventory.
Temporal Congruity	1.0	1.0	1.0	The factor is developed for and applicable to the same temporal scale.	Activity data are specific to the temporal period represented in the inventory.
Composite Scores	0.88	0.98	0.85		

TABLE 7.6-4
DARS SCORES: EMISSION FACTORS

Attribute	Factor Score	Activity Score	Emissions Score	Factor Assumptions	Activity Assumptions
Measurement/ Method	0.60	0.80 - 1.0	0.48 - 0.60	Factor is based on speciation profile applied to measurement of other pollutant.	Lower score reflects an activity rate derived from a surrogate that is indirectly related to the activity data (rather than a surrogate that has been directly related and measured); upper score reflects direct continuous measurement of activity.
Source Specificity	0.40 - 0.60	0.70 - 0.90	0.28 - 0.54	Lower score reflects a factor developed for a similar source category and it is not known if it is a subset or superset of the source of interest; upper score reflects a factor for a similar, subset or superset source category.	Lower score reflects activity that was developed for a similar process that is highly correlated to the category or process; upper score reflects activity data that is very closely related to the emissions activity.
Spatial Congruity	0.90	1.0	0.90	The factor is developed for a similar source; spatial variability is low.	Activity data are developed for and specific to the source being inventoried.

TABLE 7.6-4**(CONTINUED)**

Attribute	Factor Score	Activity Score	Emissions Score	Factor Assumptions	Activity Assumptions
Temporal Congruity	0.50 - 0.70	0.50 - 0.90	0.25 - 0.63	Lower score reflects a factor developed for a different period, where the temporal variability is expected to be moderate to high; upper score reflects a factor developed for a different period where the temporal variability is expected to be moderate to low.	Lower score reflects activity data developed for a different period, where the temporal variability is expected to be moderate to high; upper score reflects activity data that are representative of the same temporal period as the inventory, but is based on an average of several repeated periods (activity data are an average of three years, inventory is for one year).
Composite Scores	0.60 - 0.70	0.75 - 0.95	0.48 - 0.67		

This page is intentionally left blank.

7

DATA CODING PROCEDURES

This section describes the methods and codes available for characterizing emission sources at paint manufacturing facilities. Consistent categorization and coding will result in greater uniformity among inventories. In addition, the procedures described here will assist the reader who is preparing data for input to the Aerometric Information Retrieval System (AIRS) or a similar database management system. The use of Source Classification Codes (SCCs) provided in Table 7.7-1 is recommended for describing various surface coating operations. Refer to the Clearinghouse for Inventories and Emission Factors (CHIEF) bulletin board for a complete listing of SCCs for paint facilities.

7.1 SOURCE CLASSIFICATION CODES

SCCs for various components of a surface coating operation are presented in Table 7.7-1. These include the following:

- Surface Coating Application (refers to types of coatings used);
- Coating Oven;
- Thinning Solvents;
- Paper Coating;
- Large Appliances;
- Magnet Wire Surface Coating;
- Automobiles and Light-duty Trucks;
- Metal Can Coating;
- Metal Coil Coating;
- Wood Furniture Surface Coating;
- Metal Furniture Operations;

- Flat Wood Products;
- Plastic Parts;
- Prime Coating Operation;
- Cleaning/Pretreatment;
- Coating Mixing;
- Coating Storage;
- Equipment Cleanup;
- Topcoat Operation;
- Large Aircraft; and
- Miscellaneous Metal Parts.

7.2 AIRS CONTROL DEVICE CODES

Control device codes applicable to surface coating operations are presented in Table 7.7-2. These should be used to enter the type of applicable emission control device into the AIRS Facility Subsystem (AFS). The "099" control code may be used for miscellaneous control devices that do not have a unique identification code.

TABLE 7.7-1**SOURCE CLASSIFICATION CODES FOR SURFACE COATING OPERATIONS**

Source Description	Description	Process	SCC	Units
Surface Coating (Continued)	Surface Coating Application - General: Paint: Solvent-base		40200101	Tons Coating Mix Applied
	Surface Coating Application - General: Paint: Solvent-base		40200110	Gallons of Coating
	Surface Coating Application - General: Paint: Water-base		40200201	Tons Coating Mix Applied
	Surface Coating Application - General: Paint: Water-base		40200210	Gallons of Coating
	Surface Coating Application - General: Varnish/Shellac		40200301	Tons Coating Mix Applied
	Surface Coating Application - General: Varnish/Shellac		40200310	Gallons of Coating
	Surface Coating Application - General: Lacquer		40200401	Tons Coating Mix Applied
	Surface Coating Application - General: Lacquer		40200410	Gallons of Coating
	Surface Coating Application - General: Enamel		40200501	Tons Coating Mix Applied
	Surface Coating Application - General: Enamel		40200510	Gallons of Coating
	Surface Coating Application - General: Primer		40200601	Tons Coating Mix Applied
	Surface Coating Application - General: Primer		40200610	Gallons of Coating
	Surface Coating Application - General: Adhesive Application		40200701	Tons Coating Mix Applied
	Surface Coating Application - General: Adhesive: Roll-on		40200712	Gallons Adhesive Applied
	Coating Oven - General		40200801	Tons of Coating
	Coating Oven - General: Dried < 175°F		40200802	Tons of Coating
	Coating Oven - General: Baked > 175°F		40200803	Tons of Coating

TABLE 7.7-1**(CONTINUED)**

Source Description	Description	Process	SCC	Units
Surface Coating (Continued)	Coating Oven - General: General		40200810	Gallons of Coating
	Coating Oven - General: Prime/Base Coat Oven		40200820	Tons of Coating
	Coating Oven - General: Topcoat Oven		40200830	Tons of Coating
	Coating Oven - General: Two Piece Can Curing Ovens: General (Includes Codes 41, 42, and 43)		40200840	Tons of Coating
	Coating Oven - General: Two Piece Can Base Coat Oven		40200841	Tons of Coating
	Coating Oven - General: Two Piece Can Over Varnish Oven		40200842	Tons of Coating
	Coating Oven - General: Two Piece Can Interior Body Coat Oven		40200843	Tons of Coating
	Coating Oven - General: Three Piece Can Curing Ovens (Includes Codes 46, 47, 48, and 49)		40200845	Tons of Coating
	Coating Oven - General: Three Piece Can Sheet Base Coat (Interior) Oven		40200846	Tons of Coating
	Coating Oven - General: Three Piece Can Sheet Base Coat (Exterior) Oven		40200847	Tons of Coating
	Coating Oven - General: Three Piece Can Sheet Lithographic Coating Oven		40200848	Tons of Coating
	Coating Oven - General: Three Piece Can Interior Body Coat Oven		40200849	Tons of Coating
	Coating Oven - General: Filler Oven		40200855	Tons of Coating
	Coating Oven - General: Sealer Oven		40200856	Tons of Coating
	Coating Oven - General: Single Coat Application: Oven		40200861	Tons of Coating

TABLE 7.7-1**(CONTINUED)**

Source Description	Process Description	SCC	Units
Surface Coating (Continued)	Coating Oven - General: Color Coat Oven	40200870	Tons of Coating
	Coating Oven - General: Topcoat/Texture Coat Oven	40200871	Tons of Coating
	Coating Oven - General: EMI/RFI ^a Shielding Coat Oven	40200872	Tons of Coating
	Coating Oven - General: General	40200898	1000 Feet
	Thinning Solvents - General: General: Specify in Comments	40200901	Tons Solvent
	Thinning Solvents - General: Acetone	40200902	Tons Solvent
	Thinning Solvents - General: Butyl Acetate	40200903	Tons Solvent
	Thinning Solvents - General: Butyl Alcohol	40200904	Tons Solvent
	Thinning Solvents - General: Carbitol	40200905	Tons Solvent
	Thinning Solvents - General: Cellosolve	40200906	Tons Solvent
	Thinning Solvents - General: Cellosolve Acetate	40200907	Tons Solvent
	Thinning Solvents - General: Dimethyl Formamide	40200908	Tons Solvent
	Thinning Solvents - General: Ethyl Acetate	40200909	Tons Solvent
	Thinning Solvents - General: Ethyl Alcohol	40200910	Tons Solvent
	Thinning Solvents - General: Gasoline	40200911	Tons Solvent
	Thinning Solvents - General: Isopropyl Alcohol	40200912	Tons Solvent
	Thinning Solvents - General: Isopropyl Acetate	40200913	Tons Solvent
	Thinning Solvents - General: Kerosene	40200914	Tons Solvent
	Thinning Solvents - General: Lactol Spirits	40200915	Tons Solvent
	Thinning Solvents - General: Methyl Acetate	40200916	Tons Solvent

^aEMI/RFI = electromagnetic interference/radio frequency interference.

TABLE 7.7-1

(CONTINUED)

Source Description	Process Description	SCC	Units
Surface Coating (Continued)	Thinning Solvents - General: Methyl Alcohol	40200917	Tons Solvent
	Thinning Solvents - General: Methyl Ethyl Ketone	40200918	Tons Solvent
	Thinning Solvents - General: Methyl Isobutyl Ketone	40200919	Tons Solvent
	Thinning Solvents - General: Mineral Spirits	40200920	Tons Solvent
	Thinning Solvents - General: Naphtha	40200921	Tons Solvent
	Thinning Solvents - General: Toluene	40200922	Tons Solvent
	Thinning Solvents - General: Varsol	40200923	Tons Solvent
	Thinning Solvents - General: Xylene	40200924	Tons Solvent
	Thinning Solvents - General: Benzene	40200925	Tons Solvent
	Thinning Solvents - General: Turpentine	40200926	Tons Solvent
	Thinning Solvents - General: Hexylene Glycol	40200927	Tons Solvent
	Thinning Solvents - General: Ethylene Oxide	40200928	Tons Solvent
	Thinning Solvents - General: 1,1,1-Trichloroethane (Methyl Chloroform)	40200929	Tons Solvent
	Thinning Solvents - General: Methylene Chloride	40200930	Tons Solvent
	Thinning Solvents - General: Perchloroethylene	40200931	Tons Solvent
	Thinning Solvents - General: General: Specify in Comments	40200998	Gallons Solvent
	Paper Coating: Coating Operation	40201301	Tons Solvent in Coating
	Paper Coating: Coating Mixing	40201303	Tons Solvent in Coating
	Paper Coating: Coating Storage	40201304	Tons Solvent in Coating

TABLE 7.7-1**(CONTINUED)**

Source Description	Process Description	SCC	Units
Surface Coating (Continued)	Paper Coating: Equipment Cleanup	40201305	Tons Solvent in Coating
	Paper Coating: Coating Application: Reverse Roll Coater	40201320	1000 Sq. Ft. Product Surface Area Coated
	Paper Coating: Coating Application: Rotogravure Printer	40201330	1000 Sq. Ft. Product Surface Area Coated
	Paper Coating: Other Not Classified	40201399	Tons Solvent in Coating
	Large Appliances: Prime Coating Operation	40201401	Tons Solvent in Coating
	Large Appliances: Cleaning/Pretreatment	40201402	Tons Solvent in Coating
	Large Appliances: Coating Mixing	40201403	Tons Solvent in Coating
	Large Appliances: Coating Storage	40201404	Tons Solvent in Coating
	Large Appliances: Equipment Cleanup	40201405	Tons Solvent in Coating
	Large Appliances: Topcoat Spray	40201406	Tons Solvent in Coating
	Large Appliances: Prime Coat Flashoff	40201410	1000 Sq. Ft. Product Surface Area Coated
	Large Appliances: Topcoat Flashoff	40201411	1000 Sq. Ft. Product Surface Area Coated
	Large Appliances: Coating Line: General	40201431	Appliances Produced
	Large Appliances: Prime Air Spray	40201432	1000 Sq. Ft. Product Surface Area Coated
	Large Appliances: Prime Electrostatic Spray	40201433	1000 Sq. Ft. Product Surface Area Coated

TABLE 7.7-1**(CONTINUED)**

Source Description	Process Description	SCC	Units
Surface Coating (Continued)	Large Appliances: Prime Flow Coat	40201434	1000 Sq. Ft. Product Surface Area Coated
	Large Appliances: Prime Dip Coat	40201435	1000 Sq. Ft. Product Surface Area Coated
	Large Appliances: Prime Electrodeposition	40201436	1000 Sq. Ft. Product Surface Area Coated
	Large Appliances: Top Air Spray	40201437	1000 Sq. Ft. Product Surface Area Coated
	Large Appliances: Top Electrostatic Spray	40201438	1000 Sq. Ft. Product Surface Area Coated
	Large Appliances: Other Not Classified	40201499	Tons Solvent in Coating
	Magnet Wire Surface Coating: Coating/Application/Curing	40201501	Tons Solvent in Coating
	Magnet Wire Surface Coating: Cleaning/Pretreatment	40201502	Tons Solvent in Coating
	Magnet Wire Surface Coating: Coating Mixing	40201503	Tons Solvent in Coating
	Magnet Wire Surface Coating: Coating Storage	40201504	Tons Solvent in Coating
	Magnet Wire Surface Coating: Equipment Cleanup	40201505	Tons Solvent in Coating
	Magnet Wire Surface Coating: Coating Line: General	40201531	Coating Lines
	Magnet Wire Surface Coating: Other Not Classified	40201599	Tons Solvent in Coating
	Automobiles and Light Trucks: Prime Application/Electrodeposition/Dip/Spray	40201601	Tons Solvent in Coating
	Automobiles and Light Trucks: Cleaning/Pretreatment	40201602	Tons Solvent in Coating

TABLE 7.7-1**(CONTINUED)**

Source Description	Process Description	SCC	Units
Surface Coating (Continued)	Automobiles and Light Trucks: Coating Mixing	40201603	Tons Solvent in Coating
	Automobiles and Light Trucks: Coating Storage	40201604	Tons Solvent in Coating
	Automobiles and Light Trucks: Equipment Cleanup	40201605	Tons Solvent in Coating
	Automobiles and Light Trucks: Topcoat Operation	40201606	Tons Solvent in Coating
	Automobiles and Light Trucks: Sealers	40201607	Gallons Sealer Used
	Automobiles and Light Trucks: Deadeners	40201608	Gallons Deadener Used
	Automobiles and Light Trucks: Anti-corrosion Priming	40201609	Gallons Primer Used
	Automobiles and Light Trucks: Prime Surfacing Operation	40201619	Tons Solvent in Coating
	Automobiles and Light Trucks: Repair Topcoat Application Area	40201620	Tons Solvent in Coating
	Automobiles and Light Trucks: Prime Coating: Solvent-borne - Automobiles	40201621	Vehicles Produced
	Automobiles and Light Trucks: Prime Coating: Electro-deposition - Automobiles	40201622	Vehicles Produced
	Automobiles and Light Trucks: Guide Coating: Solvent-borne - Automobiles	40201623	Vehicles Produced
	Automobiles and Light Trucks: Guide Coating: Water-borne - Automobiles	40201624	Vehicles Produced
	Automobiles and Light Trucks: Topcoat: Solvent-borne - Automobiles	40201625	Vehicles Produced
	Automobiles and Light Trucks: Topcoat: Water-borne - Automobiles	40201626	Vehicles Produced

TABLE 7.7-1**(CONTINUED)**

Source Description	Process Description	SCC	Units
Surface Coating (Continued)	Automobiles and Light Trucks: Prime Coating: Solvent-borne - Light Trucks	40201627	Vehicles Produced
	Automobiles and Light Trucks: Prime Coating: Electrodeposition - Light Trucks	40201628	Vehicles Produced
	Automobiles and Light Trucks: Guide Coating: Solvent-borne - Light Trucks	40201629	Vehicles Produced
	Automobiles and Light Trucks: Guide Coating: Water-borne - Light Trucks	40201630	Vehicles Produced
	Automobiles and Light Trucks: Topcoat: Solvent-borne - Light Trucks	40201631	Vehicles Produced
	Automobiles and Light Trucks: Topcoat: Water-borne - Light Trucks	40201632	Vehicles Produced
	Automobiles and Light Trucks: Other Not Classified	40201699	Tons Solvent in Coating
	Metal Can Coating: Cleaning/Pretreatment	40201702	Tons Solvent in Coating
	Metal Can Coating: Coating Mixing	40201703	Tons Solvent in Coating
	Metal Can Coating: Coating Storage	40201704	Tons Solvent in Coating
	Metal Can Coating: Equipment Cleanup	40201705	Tons Solvent in Coating
	Metal Can Coating: Solvent Storage	40201706	1000 Gallons Capacity
	Metal Can Coating: Two-piece Exterior Base Coating	40201721	Tons Solvent in Coating
	Metal Can Coating: Interior Spray Coating	40201722	Tons Solvent in Coating
	Metal Can Coating: Sheet Base Coating (Interior)	40201723	Tons Solvent in Coating

TABLE 7.7-1**(CONTINUED)**

Source Description	Process Description	SCC	Units
Surface Coating (Continued)	Metal Can Coating: Sheet Base Coating (Exterior)	40201724	Tons Solvent in Coating
	Metal Can Coating: Side Seam Spray Coating	40201725	Tons Solvent in Coating
	Metal Can Coating: End Sealing Compound (Also See 4-02-017-36 & -37)	40201726	Tons Solvent in Coating
	Metal Can Coating: Lithography	40201727	Tons Solvent in Coating
	Metal Can Coating: Over Varnish	40201728	Tons Solvent in Coating
	Metal Can Coating: Exterior End Coating	40201729	Coating Lines
	Metal Can Coating: Three-piece Can Sheet Base Coating	40201731	Coating Lines
	Metal Can Coating: Three-piece Can Sheet Lithographic Coating Line	40201732	Coating Lines
	Metal Can Coating: Three-piece Can Side Seam Spray Coating	40201733	Coating Lines
	Metal Can Coating: Three-piece Can Interior Body Spray Coat	40201734	Coating Lines
	Metal Can Coating: Two-piece Can Coating Line	40201735	Coating Lines
	Metal Can Coating: Two-piece Can End Sealing Compound	40201736	Coating Lines
	Metal Can Coating: Three-piece Can End Sealing Compound	40201737	Coating Lines
	Metal Can Coating: Two-piece Can Lithographic Coating Line	40201738	Coating Lines
	Metal Can Coating: Three-piece Can Coating Line (All Coating Solvent Emission Points)	40201739	Coating Lines

**TABLE 7.7-1
(CONTINUED)**

Source Description	Process Description	SCC	Units
Surface Coating (Continued)	Metal Can Coating: Other Not Classified	40201799	Tons Solvent in Coating
	Metal Coil Coating: Prime Coating Application	40201801	Tons Solvent in Coating
	Metal Coil Coating: Cleaning/Pretreatment	40201802	Tons Solvent in Coating
	Metal Coil Coating: Solvent Mixing	40201803	Tons Solvent in Coating
	Metal Coil Coating: Solvent Storage (Use 4-07-004-01 through 4-07-999-98 if possible)	40201804	Tons Solvent in Coating
	Metal Coil Coating: Equipment Cleanup	40201805	Tons Solvent in Coating
	Metal Coil Coating: Finish Coating	40201806	Tons Solvent in Coating
	Metal Coil Coating: Coating Storage	40201807	Tons Solvent in Coating
	Metal Coil Coating: Other Not Classified	40201899	Tons Solvent in Coating
	Wood Furniture Surface Coating: Coating Operation	40201901	Tons Solvent in Coating
	Wood Furniture Surface Coating: Coating Mixing	40201903	Tons Solvent in Coating
	Wood Furniture Surface Coating: Coating Storage	40201904	Tons Solvent in Coating
	Wood Furniture Surface Coating: Other Not Classified	40201999	Tons Solvent in Coating
	Metal Furniture Operations: Coating Operation	40202001	Tons Solvent in Coating
	Metal Furniture Operations: Cleaning/Pretreatment	40202002	Tons Solvent in Coating
	Metal Furniture Operations: Coating Mixing	40202003	Tons Solvent in Coating

TABLE 7.7-1**(CONTINUED)**

Source Description	Process Description	SCC	Units
Surface Coating (Continued)	Metal Furniture Operations: Coating Storage	40202004	Tons Solvent in Coating
	Metal Furniture Operations: Equipment Cleanup	40202005	Tons Solvent in Coating
	Metal Furniture Operations: Prime Coat Application	40202010	1000 Sq. Ft. Product Surface Area Coated
	Metal Furniture Operations: Prime Coat Application: Spray, High Solids	40202011	1000 Sq. Ft. Product Surface Area Coated
	Metal Furniture Operations: Prime Coat Application: Spray, Water-borne	40202012	1000 Sq. Ft. Product Surface Area Coated
	Metal Furniture Operations: Prime Coat Application: Dip	40202013	1000 Sq. Ft. Product Surface Area Coated
	Metal Furniture Operations: Prime Coat Application: Flow Coat	40202014	1000 Sq. Ft. Product Surface Area Coated
	Metal Furniture Operations: Prime Coat Application: Flashoff	40202015	1000 Sq. Ft. Product Surface Area Coated
	Metal Furniture Operations: Topcoat Application	40202020	1000 Sq. Ft. Product Surface Area Coated
	Metal Furniture Operations: Topcoat Application: Spray, High Solids	40202021	1000 Sq. Ft. Product Surface Area Coated
	Metal Furniture Operations: Topcoat Application: Spray, Water-borne	40202022	1000 Sq. Ft. Product Surface Area Coated
	Metal Furniture Operations: Topcoat Application: Dip	40202023	1000 Sq. Ft. Product Surface Area Coated
	Metal Furniture Operations: Topcoat Application: Flow Coat	40202024	1000 Sq. Ft. Product Surface Area Coated
	Metal Furniture Operations: Topcoat Application: Flashoff	40202025	1000 Sq. Ft. Product Surface Area Coated
	Metal Furniture Operations: Single Spray Line: General	40202031	1000 Sq. Ft. Product Surface Area Coated
	Metal Furniture Operations: Spray Dip Line: General (Use 4-01-20-37)	40202032	1000 Sq. Ft. Product Surface Area Coated

TABLE 7.7-1**(CONTINUED)**

Source Description	Process Description	SCC	Units
Surface Coating (Continued)	Metal Furniture Operations: Spray High Solids Coating (Use 4-02-020-35)	40202033	1000 Sq. Ft. Product Surface Area Coated
	Metal Furniture Operations: Spray Water-borne Coating (Use 4-02-020-36)	40202034	1000 Sq. Ft. Product Surface Area Coated
	Metal Furniture Operations: Single Coat Application: Spray, High Solids	40202035	1000 Sq. Ft. Product Surface Area Coated
	Metal Furniture Operations: Single Coat Application: Spray, Water-borne	40202036	1000 Sq. Ft. Product Surface Area Coated
	Metal Furniture Operations: Single Coat Application: Dip	40202037	1000 Sq. Ft. Product Surface Area Coated
	Metal Furniture Operations: Single Coat Application: Flow Coat	40202038	1000 Sq. Ft. Product Surface Area Coated
	Metal Furniture Operations: Single Coat Application: Flashoff	40202039	1000 Sq. Ft. Product Surface Area Coated
	Metal Furniture Operations: Other Not Classified	40202099	Tons Solvent in Coating
	Flatwood Products: Base Coat	40202101	Tons Solvent in Coating
	Flatwood Products: Coating Mixing	40202103	Tons Solvent in Coating
	Flatwood Products: Coating Storage	40202104	Tons Solvent in Coating
	Flatwood Products: Equipment Cleanup	40202105	Tons Solvent in Coating
	Flatwood Products: Topcoat	40202106	Tons Solvent in Coating
	Flatwood Products: Filler	40202107	Tons Solvent in Coating
	Flatwood Products: Sealer	40202108	Tons Solvent in Coating
	Flatwood Products: Inks	40202109	Tons Solvent in Coating

TABLE 7.7-1**(CONTINUED)**

Source Description	Process Description	SCC	Units
Surface Coating (Continued)	Flatwood Products: Grove Coat Application	40202110	Tons Solvent in Coating
	Flatwood Products: Stain Application	40202111	Tons Solvent in Coating
	Flatwood Products: Filler Sander	40202117	1000 Sq. Ft. of Product
	Flatwood Products: Sealer Sander	40202118	1000 Sq. Ft. of Product
	Flatwood Products: Water-borne Coating	40202131	1000 Sq. Ft. of Product Surface Area Coated
	Flatwood Products: Solvent-borne Coating	40202132	1000 Sq. Ft. of Product Surface Area Coated
	Flatwood Products: Ultraviolet Coating	40202133	1000 Sq. Ft. of Product Surface Area Coated
	Flatwood Products: Surface Preparation (Includes Tempering, Sanding, Brushing, and Grove Cut)	40202140	1000 Sq. Ft. of Product
	Flatwood Products: Other Not Classified	40202199	Tons Solvent in Coating
	Plastic Parts: Coating Operation	40202201	Tons Solvent in Coating
	Plastic Parts: Cleaning/Pretreatment	40202202	Tons Solvent in Coating
	Plastic Parts: Coating Mixing	40202203	Tons Solvent in Coating
	Plastic Parts: Coating Storage	40202204	Tons Solvent in Coating
	Plastic Parts: Equipment Cleanup	40202205	Tons Solvent in Coating
	Plastic Parts: Business: Baseline Coating Mix	40202206	Square Feet

TABLE 7.7-1**(CONTINUED)**

Source Description	Process Description	SCC	Units
Surface Coating (Continued)	Plastic Parts: Business: Low Solids Solvent-borne Coating	40202207	Square Feet
	Plastic Parts: Business: Medium Solids Solvent-borne Coating	40202208	Square Feet
	Plastic Parts: Business: High Solids Coating (25% Efficiency)	40202209	Square Feet
	Plastic Parts: Business: High Solids Solvent-borne Coating (40% Efficiency)	40202210	Square Feet
	Plastic Parts: Business: Water-borne Coating	40202211	Square Feet
	Plastic Parts: Business: Low Solids Solvent-borne EMI/RFI ^a Shielding Coating	40202212	Square Feet
	Plastic Parts: Business: High Solids Solvent-borne EMI/RFI ^a Shielding Coating	40202214	Square Feet
	Plastic Parts: Business: Zinc Arc Spray	40202215	Square Feet
	Plastic Parts: Prime Coat Application	40202220	Square Feet
	Plastic Parts: Prime Coat Flashoff	40202229	Square Feet
	Plastic Parts: Color Coat Application	40202230	Square Feet
	Plastic Parts: Color Coat Flashoff	40202239	Square Feet
	Plastic Parts: Topcoat/Texture Coat Application	40202240	Square Feet
	Plastic Parts: Topcoat/Texture Coat Flashoff	40202249	Square Feet
	Plastic Parts: EMI/RFI ^a Shielding Coat Application	40202250	Square Feet
	Plastic Parts: EMI/RFI ^a Shielding Coat Flashoff	40202259	Square Feet
	Plastic Parts: Sanding/Grit Blasting Prior to EMI/RFI Shielding Coat Application	40202270	Square Feet
	Plastic Parts: Maskant Application	40202280	Square Feet
	Plastic Parts: Other Not Classified	40202299	Tons Solvent in Coating

**TABLE 7.7-1
(CONTINUED)**

Source Description	Process Description	SCC	Units
Surface Coating (Continued)	Prime Coating Operation	40202301	Tons Solvent in Coating
	Cleaning/Pretreatment	40202302	Tons Solvent in Coating
	Coating Mixing	40202303	Tons Solvent in Coating
	Coating Storage	40202304	Tons Solvent in Coating
	Equipment Cleanup	40202305	Tons Solvent in Coating
	Topcoat Operation	40202306	Tons Solvent in Coating
	Large Aircraft: Prime Coating Operation	40202401	Tons Solvent in Coating
	Large Aircraft: Cleaning/Pretreatment	40202402	Tons Solvent in Coating
	Large Aircraft: Coating Mixing	40202403	Tons Solvent in Coating
	Large Aircraft: Coating Storage	40202404	Tons Solvent in Coating
	Large Aircraft: Equipment Cleanup	40202405	Tons Solvent in Coating
	Large Aircraft: Topcoat Operation	40202406	Tons Solvent in Coating
	Large Aircraft: Other Not Classified	40202499	Tons Solvent in Coating
	Miscellaneous Metal Parts: Coating Operation	40202501	Tons Solvent in Coating
	Miscellaneous Metal Parts: Cleaning/Pretreatment	40202502	Tons Solvent in Coating
	Miscellaneous Metal Parts: Coating Mixing	40202503	Tons Solvent in Coating

TABLE 7.7-1**(CONTINUED)**

Source Description	Process Description	SCC	Units
Surface Coating (Continued)	Miscellaneous Metal Parts: Coating Storage	40202504	Tons Solvent in Coating
	Miscellaneous Metal Parts: Equipment Cleanup	40202505	Tons Solvent in Coating
	Miscellaneous Metal Parts: Prime Coat Application	40202510	1000 Sq. Ft. Product Surface Area Coated
	Miscellaneous Metal Parts: Prime Coat Application: Spray, High Solids	40202511	1000 Sq. Ft. Product Surface Area Coated
	Miscellaneous Metal Parts: Prime Coat Application: Spray, Water-borne	40202512	1000 Sq. Ft. Product Surface Area Coated
	Miscellaneous Metal Parts: Prime Coat Application: Flashoff	40202515	1000 Sq. Ft. Product Surface Area Coated
	Miscellaneous Metal Parts: Topcoat Application	40202520	1000 Sq. Ft. Product Surface Area Coated
	Miscellaneous Metal Parts: Topcoat Application: Spray, High Solids	40202521	1000 Sq. Ft. Product Surface Area Coated
	Miscellaneous Metal Parts: Topcoat Application: Spray, High Solids	40202522	1000 Sq. Ft. Product Surface Area Coated
	Miscellaneous Metal Parts: Topcoat Application: Dip	40202523	1000 Sq. Ft. Product Surface Area Coated
	Miscellaneous Metal Parts: Topcoat Application: Flow Coat	40202524	1000 Sq. Ft. Product Surface Area Coated
	Miscellaneous Metal Parts: Topcoat Application: Flashoff	40202525	1000 Sq. Ft. Product Surface Area Coated
	Miscellaneous Metal Parts: Conveyor Single Flow	40202531	1000 Sq. Ft. Product Surface Area Coated
	Miscellaneous Metal Parts: Conveyor Single Dip	40202532	1000 Sq. Ft. Product Surface Area Coated
	Miscellaneous Metal Parts: Conveyor Single Spray	40202533	1000 Sq. Ft. Product Surface Area Coated
	Miscellaneous Metal Parts: Conveyor Two Coat, Flow and Spray	40202534	1000 Sq. Ft. Product Surface Area Coated

TABLE 7.7-1**(CONTINUED)**

Source Description	Process Description	SCC	Units
Surface Coating (Continued)	Miscellaneous Metal Parts: Conveyor Two Coat, Dip and Spray	40202535	1000 Sq. Ft. Product Surface Area Coated
	Miscellaneous Metal Parts: Conveyor Two Coat, Spray	40202536	1000 Sq. Ft. Product Surface Area Coated
	Miscellaneous Metal Parts: Manual Two Coat, Spray and Air Dry	40202537	1000 Sq. Ft. Product Surface Area Coated
	Miscellaneous Metal Parts: Single Coat Application: Spray, High Solids	40202542	1000 Sq. Ft. Product Surface Area Coated
	Miscellaneous Metal Parts: Single Coat Application: Spray, Water-borne	40202543	1000 Sq. Ft. Product Surface Area Coated
	Miscellaneous Metal Parts: Single Coat Application: Dip	40202544	1000 Sq. Ft. Product Surface Area Coated
	Miscellaneous Metal Parts: Single Coat Application: Flow Coat	40202545	1000 Sq. Ft. Product Surface Area Coated
	Miscellaneous Metal Parts: Single Coat Application: Flashoff	40202546	1000 Sq. Ft. Product Surface Area Coated
	Miscellaneous Metal Parts: Other Not Classified	40202599	Tons Solvent in Coating

TABLE 7.7-2
AIRS CONTROL DEVICE CODES

Control Device	Code
Wet Scrubber-High Efficiency	001
Wet Scrubber-Medium Efficiency	002
Wet Scrubber-Low Efficiency	003
Mist Eliminators-High Velocity	014
Mist Eliminators-Low Velocity	015
Catalytic Afterburners	019
Catalytic Afterburners with Heat Exchanges	020
Direct-Flame Afterburners	021
Direct-Flame Afterburners with Heat Exchanges	022
Flares	023
Activated Carbon Adsorption	048
Packed-Gas Absorption Column	050
Tray-Type Gas Adsorption Column	051
Impingement Plate Scrubber	055
Mat or Panel Filter	058
Dust Suppression by Water Sprays	061
Process Modifications-Electrostatic Spraying	105
Refrigerated Condenser	073
Barometric Condenser	074
Process Modification-Water-borne Coatings	101
Process Modification-Low Solvent Coatings	102
Process Modification-Power Coatings	103
Miscellaneous Control Device	099

REFERENCES

California Air Resources Board (CARB). 1994. *Survey of Emissions from Solvent Use--Volume I: Aerosol Paints and Volume II: Architectural Surface Coatings*.

California Environmental Protection Agency, Air Resources Board.

Code of Federal Regulations (CFR). Title 40, Part 63. December 6, 1994. National Emission Standards for Hazardous Air Pollutants; Proposed Standards for Hazardous Air Pollutant Emissions from Wood Furniture Manufacturing Operations. Office of the Federal Register, Washington, D.C.

Eisenmann Corporation. VOC Emissions Control Systems, Brochures and Illustrations, Crystal Lake, Illinois.

EPA. 1977a. *Control of Volatile Organic Emissions from Existing Stationary Sources, Volume III: Surface Coating of Metal Furniture*. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, EPA-450/2-77-032. Research Triangle Park, North Carolina.

EPA. 1977b. *Control of Volatile Organic Emissions from Existing Stationary Sources, Volume V: Surface Coating of Large Appliances*. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, EPA-450/2-77-034. Research Triangle Park, North Carolina.

EPA. 1977c. *Control of Volatile Organic Emissions from Existing Stationary Sources, Volume II: Surface Coating of Cans, Coils, Paper, Fabrics, Automobiles, and Light Duty Trucks*. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, EPA-450/2-77-008. Research Triangle Park, North Carolina.

EPA. 1977d. *Control of Volatile Organic Emissions from Existing Stationary Sources, Volume IV: Surface Coating for Insulation of Magnet Wire*. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, EPA-450/2-77-033. Research Triangle Park, North Carolina.

EPA. 1978. *Control of Volatile Organic Emissions from Existing Stationary Sources, Volume V: Surface Coating of Miscellaneous Metal Parts and Products*. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, EPA 450/2-78-015. Research Triangle Park, North Carolina.

EPA. 1979. *Automobile and Light-Duty Truck Surface Coating Operations - Background Information for Proposed Standards*. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, EPA 450/3-79-030. Research Triangle Park, North Carolina.

EPA. 1991. *Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone. Volume I: General Guidance for Stationary Sources*. U.S. Environmental Protection Agency, EPA-450/4-91-016. Research Triangle Park, North Carolina.

EPA. 1992. *Control of VOC Emissions from Ink and Paint Manufacturing Processes*. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, EPA 450/3-92-013. Research Triangle Park, North Carolina.

EPA. 1994a. *Alternative Control Techniques Document: Automobile Refinishing*. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, EPA 453/R-94-031. Research Triangle Park, North Carolina.

EPA. 1994b. *Alternative Control Techniques Document: Surface Coatings Operation at Shipbuilding and Ship Repair Facilities*. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, EPA 453/R-94-032. Research Triangle Park, North Carolina.

EPA. 1995a. *Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources, Fifth Edition, AP-42, Section 4.0, Surface Coating*, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

EPA. 1995b. *Factor Information and Retrieval (FIRE) Data System, Version 5.1*. Updated Annually. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

Texas Air Control Board (TACB). May 1, 1993. *Texas Air Control Board Guideline Package for Spray Painting and Dip Coating Operations*. TACB, Austin, Texas.¹

Turner, Mark B. 1992. Surface Coating. Anthony J. Buonicore and Wayne T. Davis, editors. In: *Air Pollution Engineering Manual*. Van Nostrand Reinhold, New York, New York.

¹ The Texas Air Control Board (TACB) has since been renamed the Texas Natural Resource Conservation Commission (TNRCC).

APPENDIX A

EXAMPLE DATA COLLECTION FORM INSTRUCTIONS FOR SURFACE COATING OPERATIONS

This page is intentionally left blank.

EXAMPLE DATA COLLECTION FORM INSTRUCTIONS FOR SURFACE COATING OPERATIONS

1. This form may be used as a work sheet to aid the plant engineer in collecting the information necessary to calculate emissions from each surface coating operation. The information requested on the form relates to the methods (described in Sections 3 and 4) for quantifying emissions. This form may also be used by the regulatory agency to assist in area-wide inventory preparation.
2. The completed forms should be maintained in a reference file by the plant engineer with other supporting documentation.
3. If the information requested is unknown, write "unknown" in the blank. If the information requested does not apply to a particular unit or process, write "NA" in the blank.
4. If you want to modify the form to better serve your needs, an electronic copy of the form may be obtained through the EIIP on the CHIEF bulletin board system (BBS).
5. If hourly or monthly material use information is not available, enter the information in another unit (quarterly or yearly). Be sure to indicate the unit of measure on the form.
6. Use the comments field on the form to record all useful information that will allow your work to be reviewed and reconstructed.
7. Collect all Manufacturer's Technical Specification (Data) Sheets for all materials containing potential air contaminants that are used at the facility.
8. For each material used, determine maximum hourly usage rates and annual usage rates.
9. The plant engineer should maintain all material usage information and Technical Specification (Data) Sheets in a reference file.
10. Revisions should be made as appropriate and necessary to make data collection consistent with permit categorization.

EXAMPLE DATA COLLECTION FORM - SURFACE COATING OPERATIONS**GENERAL INFORMATION**

Facility/Plant Name: _____

SIC Code: _____

SCC: _____

SCC Description: _____

Location: _____

County: _____

City: _____

State: _____

Plant Geographical Coordinates:

Latitude: _____

Longitude: _____

UTM Zone: _____

UTM Easting: _____

UTM Northing: _____

Contact Name: _____

Title: _____

Telephone Number: _____

Unit ID Number: _____

Permit Number: _____

EXAMPLE DATA COLLECTION FORM - SURFACE COATING OPERATIONS

EQUIPMENT AND PROCESS INFORMATION	COMMENTS	
Name or description of equipment:		
Make:		
Model:		
Rated capacity of equipment:		
Type of operation:		
Surface coater:		
Dryer:		
Printing press:		
Other:		
Type of equipment for this operation:		
Dip coater:		
Letter press:		
Other:		
Application/Dryer evaporation split (%):		
Typical use:		
Hours/day:		
Days/week:		
Weeks/year:		
Seasonal variations (%):		
January:	February:	March:
April:	May:	June:
July:	August:	September:
October:	November:	December:

Solvent Composition	Annual Usage (gal/yr)	Percent of Total Solvents Listed	Molecular Weight (lb/lb-mole)	Liquid Density (lb/gal)
Total				
Solvent Molecular Weight (weighted average), (MW _i)			lb/lb-mole	
Solvent Liquid Density (weighted average), (d _i)			lb/lb-mole	

$$Y = \sum_{i=1}^n (x_i * y_i)$$

Y = Weighted average molecular weight (M_i) or liquid density (d_i)
n = Number of VOC species in the solvent(s)
 y_i = Molecular weight (MW_i) or liquid density (d_i) for VOC_i
 x_i = Fraction of total solvent for VOC_i

WORKSHEET B

SPRAY BOOTHS

Booth ID No.:							
Annual Hours of Operation of this Booth:							
EXHAUST GAS STREAM CHARACTERISTICS							
Flow Rate (acfm)		Exhaust Stack			Building Height (ft)	Abatement Device Particulate Loading (lb/hr)	
Design Maximum	Average Expected	Temperature (°F)	Height (ft)	Diameter (ft)		Inlet	Outlet
TYPE OF COATING AND MAXIMUM RATE OF USE							
<u>Type</u>	<u>Max. Rate of Use (lb/hr)</u>		<u>Max. Rate of Use (ton/yr)</u>		<u>Volatile Portion (%weight)</u>		
Lacquer	_____		_____		_____		
Varnish	_____		_____		_____		
Enamel	_____		_____		_____		
Metal Primer	_____		_____		_____		
Metal Spray	_____		_____		_____		
Resin	_____		_____		_____		
Sealer	_____		_____		_____		
Shellac	_____		_____		_____		
Stain	_____		_____		_____		
Zinc Chromate	_____		_____		_____		
Epoxy	_____		_____		_____		
Polyurethane	_____		_____		_____		
Other	_____		_____		_____		
SOLVENT COMPOSITION AND RATE OF USE (INCLUDE THAT SUPPLIED WITH COATING)							
<u>Chemical Composition of Volatiles & Wt. (%)</u>			<u>Max. Rate of Use (lb/hr)</u>		<u>Max. Rate of Use(ton/yr)</u>		
_____			_____		_____		
_____			_____		_____		
_____			_____		_____		
_____			_____		_____		
TYPE OF PM ABATEMENT DEVICE							
<input type="checkbox"/> Spray Chamber (water use gal/hr) _____ <input type="checkbox"/> Dry <input type="checkbox"/> Water Curtain (water use gal/hr) _____ <input type="checkbox"/> Other Filter Pads (total number in all layers) _____ (size) _____ (explain) _____ <input type="checkbox"/> Manufacturer's Rating for PM Control Efficiency _____							
TYPE OF VOC ABATEMENT DEVICE							
Type _____				Rated Control Efficiency _____			

**WORKSHEET B
(CONTINUED)**

METHOD OF SPRAYING	DESCRIPTION OF ITEMS TO BE COATED (SHAPE AND SIZE)
<input type="checkbox"/> Air Atomization <input type="checkbox"/> Airless Electrostatic <input type="checkbox"/> Disc <input type="checkbox"/> Airless <input type="checkbox"/> Air-Atomized <input type="checkbox"/> Other _____	

EMISSION ESTIMATION RESULTS

Pollutant	Coating Operation ID ^a	Emission Estimation Method ^b	Emissions	Emissions Units	Emission Factor ^c	Emission Factor Units	Gallons of Coating Applied	Comments
VOC								
THC								
PM ₁₀								
Total Particulate								
Hazardous Air Pollutants (list individually)								

^a Use the following codes to indicate which type of operation was used:

SC = Surface Coater
 DR = Dryer
 PP = Printing Press
 O = Other

^b Use the following codes to indicate which emission estimation method is used for each pollutant:

Material Balance = MB Emission Factor = EF
 Stack Test Data = ST Other indicate = O

^c Where applicable, enter the emission factor and provide the full citation of the reference or source of information from where the emission factor came. Include edition, version, table, and page number *HP-42* is used.